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Summary of Air Quality Monitoring in Alberta: 1990.
Air Quality Monitoring Report for Alberta: 1990 - Technical Report Series No. 92-2a.
Air Quality Monitoring Data Summary for Alberta: 1990 - Technical Report Series No. 92-2b.

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SUMMARY

Alberta Environment has conducted air quality monitoring in the province since the early 1960s. The objectives of the monitoring program are to: (1) report existing air quality; (2) determine trends of air quality; (3) inform the public of adverse air quality conditions; and (4) conduct monitoring in special problem areas. In 1990, the air quality monitoring program consisted of continuous, intermittent, static, portable, mobile and acid precipitation monitoring networks. Air quality monitoring data from continuous, intermittent, static and acid precipitation networks are summarized below. The regulations and guidelines for individual pollutants are discussed in detail in the main text of this report. Data from portable and mobile monitoring networks are available from independent Alberta Environment reports.

Continuous Air Quality Monitoring

Continuous air quality monitoring is the measurement of pollutant concentrations on an 1-hour average basis. Pollutants that are monitored continuously by Alberta Environment include ammonia, carbon monoxide, the coefficient of haze (dust and smoke), hydrogen sulphide, oxides of nitrogen (including nitrogen oxide and nitrogen dioxide), ozone, sulphur dioxide and total hydrocarbons. Continuous monitoring stations are located in downtown, residential and industrial areas of Edmonton and Calgary as well as at Fort Saskatchewan, Fort McMurray and Fort MacKay.

The Index of the Quality of the Air

The Index of the Quality of the Air (IQUA), which was developed by a federal-provincial committee in 1978, is a way of indicating air quality in simple and concise terms. The IQUA relates concentrations of five major continuously monitored pollutants (sulphur dioxide, carbon monoxide, ozone, nitrogen dioxide and coefficient of haze) to a common scale which may be easily interpreted by the public. This scale associates Good, Fair, Poor and Very Poor air quality categories to federal and provincial air quality objectives. The IQUA is reported twice daily (8:15 a.m. and 3:15 p.m.) at Edmonton and Calgary.

Good air quality was observed the majority of the time at all Alberta Environment continuous monitoring stations in 1990. The frequency of good air quality ratings ranged from 89% at the Fort McMurray monitoring station to 98% at the Calgary residential monitoring station. Fair air quality ratings were most frequent at Fort McMurray where 11% of IQUA ratings were in this category. Poor air quality ratings were most frequent at the Calgary Industrial monitoring station (0.7% or 64 hours). The majority of Poor air quality readings were due to the coefficient of haze (dust and smoke) at the Edmonton and Calgary stations and ozone at the more rural Fort McMurray and Fort Saskatchewan stations. Very Poor air quality was observed at the Edmonton Industrial monitoring station for three hours on May 25. The coefficient of haze was very high on this day due to a dust storm which transported dust from agricultural fields east of Edmonton into the industrial area of the city.

Ammonia

Ammonia is a colourless gas with a pungent odour. Ammonia is emitted into the atmosphere through natural sources such as animal decay and animal excretions, and man-made sources such as the fertilizer industry.

Exceedances of the guideline for ammonia were not recorded at the Fort Saskatchewan monitoring station. Ammonia concentrations were below the detectable limit of 0.1 ppm (parts per million) 90% of the time. The maximum ammonia concentration measured was 1.3 ppm.

Carbon Monoxide

Carbon monoxide is a colourless, odourless gas emitted into the atmosphere primarily by motor vehicles in urban areas. Minor sources of carbon monoxide include fireplaces, industry, aircraft and natural gas combustion.

Ambient carbon monoxide concentrations exceeded the 1-hour regulation at the Edmonton residential monitoring station and all Calgary monitoring stations. All of these exceedances occurred in the winter with the exception of the Edmonton residential monitoring station where exceedances of the regulation were also observed in the late fall and early spring. The 8-hour regulation for carbon monoxide was exceeded at the Edmonton residential and downtown monitoring stations and at all the Calgary monitoring stations. Again, these exceedances occurred during the winter at the Calgary stations and fall, winter and spring at the Edmonton stations. The major factors which cause these exceedances are the combination of vehicle exhaust emissions and stagnant whether conditions which do not allow pollutants to disperse rapidly. A trend toward lower carbon monoxide concentrations is evident at the Edmonton downtown and residential stations and all Calgary stations.

The Coefficient of Haze

The coefficient of haze is an indicator of dust and smoke in the atmosphere which interferes with visibility. Dust and smoke may originate from road dust, wind-blown soil, industrial sources, automobile emissions, agricultural activities and various other sources.

The guideline for the coefficient of haze (90% of values per month less than 1.0 COH (coefficient of haze) unit) was not exceeded at any monitoring stations in 1990. The highest frequency of values greater then 1.0 COH unit was 7.6% which occurred in January at the Calgary industrial monitoring site. The highest values are generally observed in the fall, winter and early spring seasons at all monitorng stations. Coefficient of haze values are much higher at urban stations in Edmonton and Calgary than at the more rural Fort Saskatchewan and Fort McMurray monitoring stations. The major sources of dust and smoke in these areas are automobiles, road dust and industry.

Hydrogen Sulphide

Hydrogen sulphide is a colourless gas with a rotten egg odour. Industrial sources include petroleum refineries, natural gas plants, petrochemical plants, coke oven plants, and pulp and paper plants which use the kraft pulping process.

Hydrogen sulphide concentrations exceeded the 1-hour regulation of 0.010 ppm at the Calgary industrial, Fort McMurray and Fort MacKay monitoring units. A maximum 1-hour average hydrogen sulphide concentration of 0.012 ppm was recorded in November at Fort McMurray. The maximum frequency of exceedances was at the Calgary industrial location where the regulation was exceeded four times. The 24-hour regulation for hydrogen sulphide was also exceeded on two occasions at this location. Sources of hydrogen sulphide in the Calgary industrial region are likely fugitive emissions from industrial activities in the region. The oil sands processing plants between Fort McMurray and Fort MacKay are the major sources of elevated hydrogen sulphide readings at these locations.

Nitrogen Dioxide

Nitrogen dioxide is a reddish-brown gas with a pungent odour. Sources of nitrogen dioxide in Alberta include the oil and gas industry, transportation (vehicle and aircraft emissions), power plants, natural gas and heating fuel combustion, and forest fires. The largest urban source of nitrogen dioxide is vehicular emissions.

The regulation for annual average nitrogen dioxide concentrations was exceeded only at the Calgary downtown monitoring station in 1990. The 1-hour, 24-hour and annual average regulations were not exceeded at any monitoring stations. The highest nitrogen dioxide concentrations were generally observed at the Edmonton downtown and residential stations as well as the Calgary downtown and industrial stations. Sources of nitrogen dioxide in these areas include vehicle exhaust and heating fuel consumption. A downward trend in nitrogen dioxide is evident at the Edmonton downtown monitoring site.

Ozone

At ambient atmospheric concentrations, ozone is a colourless, odourless gas. Ozone is generated in the atmosphere through a photochemical reaction between sunlight, nitrogen dioxide and hydrocarbons. Ozone may also be transported down to ground-level from the upper atmosphere. The build-up of ozone precursors such as oxides of nitrogen and hydrocarbons during the winter may contribute to high spring time ozone concentrations.

The 1-hour regulation for ozone was exceeded at the Fort McMurray, Fort Saskatchewan, Edmonton residential, Edmonton industrial and Calgary residential monitoring stations. The highest frequency of exceedances was at the Fort McMurray station where 18 hours exceeded the regulation. Exceedances of the 1-hour regulation were most frequent in the summer in the Edmonton and Calgary regions and in the spring at Fort McMurray. The 24-hour regulation for ozone was exceeded on numerous occasions at all

24-hour regulation, respectively. The least number of exceedances were indicated at the Edmonton and Calgary downtown monitoring stations. An upward trend in ozone concentration is evident from data collected at the Calgary downtown monitoring station.

Sulphur Dioxide

Sulphur dioxide is a colourless gas with a pungent odour. The most common sources of sulphur dioxide in Alberta are natural gas extraction plants, oil sands plants, coal-fired power plants, oil refineries, pulp and paper mills, fertilizer plants and diesel-powered transport vehicles.

Exceedances of the regulations for sulphur dioxide did not occur at any Alberta Environment monitoring stations in 1990. Maximum 1-hour average concentrations of 0.136 and 0.105 ppm were recorded at Fort MacKay and Fort McMurray monitoring locations, respectively. Elevated sulphur dioxide readings at these locations were likely due to the oil sands processing industry.

Total Hydrocarbons

The term "total hydrocarbons" refers to non-reactive and reactive hydrocarbons. Non-reactive hydrocarbons, such as methane, occur naturally in the atmosphere. Reactive hydrocarbons (or volatile organic compounds) exist in the atmosphere primarily through man-made emissions. Reactive hydrocarbons may react with sunlight to form ozone. Sources of reactive hydrocarbons include vegetation, vehicular emissions, petroleum storage tanks and other industrial activities.

The highest annual average total hydrocarbon concentrations were measured at monitoring stations located close to major traffic arteries. A maximum 1-hour average total hydrocarbon concentration of 13.5 ppm was recorded at the Edmonton industrial monitoring location. Sources of hydrocarbons in the Edmonton industrial area were likely petroleum storage tanks, refineries, vehicular emissions, painting and drycleaning. No regulations exist for ambient total hydrocarbon concentrations.

Intermittent Air Quality Monitoring

Suspended particulates were monitored at all Edmonton and Calgary continuous monitoring stations as well as at Ellerslie (15 km south-southwest of downtown Edmonton) and Fort Saskatchewan. Suspended particulates are monitored every sixth day in accordance with the National Air Pollution Surveillance (NAPS) system as a 24-hour accumulated loading. Chemical analysis is conducted on suspended particulate samples to quantify loadings of total suspended particulates, Benzo (a) Pyrene and lead. Vinyl chloride monomers were monitored, on an intermittent basis, at three locations in the Fort Saskatchewan area.

Total Suspended Particulates

Suspended particulates are particles which range from about 0.001 to 500 microns in diameter (a human hair is about 100 microns in diameter) and, depending on their density, may remain suspended in the air for an indefinite period of time. Suspended particulates may originate from soil, road and agricultural dust; smoke from forest fires and recreational fires; vehicular exhaust emissions; and industrial sources.

The 24-hour regulation for total suspended particulates was exceeded at all Edmonton and Calgary monitoring stations. The greatest frequency of exceedances was observed at the downtown monitoring stations of Edmonton and Calgary and also at the Calgary industrial monitoring station. Suspended particulate sources in these areas include vehicle exhaust, road dust and industrial emissions. Total suspended particulate loadings show a downward trend, based on 11 years of data, at the Edmonton residential monitoring station and all Calgary monitoring stations.

Benzo (a) Pyrene

Benzo (a) Pyrene is a polycyclic aromatic hydrocarbon (PAH) that is contained in all types of soot and smoke. Vehicular exhaust, and smoke from industrial and recreational emissions are the most common sources of Benzo (a) Pyrene.

Benzo (a) Pyrene loadings were generally greater at monitoring stations located close to major traffic arteries. Substantially higher Benzo (a) Pyrene values were recorded at Edmonton and Calgary downtown stations than at the less urban stations. Relatively high Benzo (a) Pyrene loadings were also observed at the Calgary industrial and Edmonton residential monitoring stations. The major source of Benzo (a) Pyrene at these locations is vehicular emissions. Based on nine years of data, Benzo (a) Pyrene loadings show a significant increase at both Edmonton and Calgary residential monitoring stations. This is most likely due to increased traffic density in these regions.

Lead

Lead is emitted into the atmosphere primarily as a result of burning leaded gasoline in motor vehicles. Other sources of atmospheric lead include iron and steel manufacturing, solid waste incineration and battery manufacturing.

Lead loadings are much higher at locations in close proximity to major traffic arteries than in rural locations. The highest annual average lead loadings were recorded at Edmonton downtown and residential, and Calgary downtown and industrial monitoring locations. A maximum annual average lead loading of 0.14 ug/m^3 (micrograms per cubic meter) was recorded at the Calgary industrial monitoring station. A trend toward lower lead loadings is obvious at all Edmonton, Calgary and Fort Saskatchewan monitoring stations. This trend is a reflection of the decrease in the use of leaded gasoline over the past decade.

Vinyl Chloride Monomer

When present in the atmosphere, vinyl chloride monomer is a colourless gas with a faint sweet odour. Vinyl chloride monomer is emitted into the atmosphere during the manufacturing of clothing, building and construction materials, home furnishings, and packaging for toys and plastics.

Average vinyl chloride monomer concentrations from August to December ranged from 0.03 ppb (parts per billion) at the Fort Saskatchewan monitoring unit to 0.06 ppb west of the Dow Chemical plant to 0.11 ppb at the monitoring location in the vicinity of the BF Goodrich processing plant. Alberta Environment does not have regulations for atmospheric concentrations of vinyl chloride monomer.

Static Air Quality Monitoring

Alberta Environment conducts air quality monitoring, on a static basis, at approximately 70 networks throughout Alberta. Each network consists of one or more monitoring stations. Static monitoring is the measurement of total accumulated loadings of pollutants on a one- and three-month schedule. Parameters monitored on a static basis include total dustfall, calcium, total sulphation, hydrogen sulphide and fluorides.

Total Dustfall

Dustfall is defined as the fraction of particulate that does not remain suspended in the atmosphere for an indefinite period of time. Sources of dustfall include wind-blown soil, road dust, dust generated by agricultural activities, ash from forest fires and recreational fires, and flyash from industrial sources.

Total dustfall loadings exceeded Alberta Environment guidelines for residential regions at most networks where total dustfall is monitored. Guidelines for industrial regions were exceeded at six of these networks. The highest frequency of exceedances occurred at the Calgary and Lethbridge networks where 47 and 43% of samples exceeded the residential guideline, respectively. The major sources of dustfall in Alberta include road dust, agricultural dust, dust from industrial sources and vehicular exhaust.

Calcium

Calcium emanates from natural sources such as wind-blown soil and road dust. Man-made sources of calcium in dustfall include cement, iron, steel and wood processing.

The highest annual average calcium loading recorded in 1990 was 14.1 mg/100 sq cm/30 days (milligrams per 100 square centimeters per 30 days) which was measured at the Exshaw network. This value is over two times the calcium loadings

recorded in the Edmonton area. This relatively high value may be attributed to cement manufacturing activities in the Exshaw vicinity.

Total Sulphation

Total sulphation is the measurement of all sulphur-containing compounds which exist in the atmosphere. Sulphur recovery gas plants, coal-burning power plants and petroleum are common sources of total sulphation.

Total sulphation was monitored at 23 networks, on a one-month basis and 35 networks on a three-month basis in Alberta. The guideline for total sulphation was not exceeded in 1990. The highest annual-average total sulphation value was also recorded at the Redwater network.

Hydrogen Sulphide

Hydrogen sulphide is present in the atmosphere from natural sources such as coal, natural gas, oil, sulphur hot springs, sloughs, swamps and lakes. Industrial sources of hydrogen sulphide include petroleum refining plants, natural gas plants, petrochemical complexes, coke oven plants, pulp and paper plants employing the kraft pulping process, and petroleum and gas gathering fields.

A total of 14 networks monitor hydrogen sulphide on a monthly basis while 35 networks monitor hydrogen sulphide on a three-month basis. Exceedances of the guideline for hydrogen sulphide did not occur at any static monitoring networks in 1990. The highest annual-average hydrogen sulphide loading was observed at the Fort McMurray and Grande Prairie networks.

Fluorides

Fluorides are emitted into the atmosphere through processes such as coal combustion and the processing of phosphate bearing rock. Alberta Environment operates four fluoride monitoring networks in the province.

Fluoride loadings were the highest at the Medicine Hat monitoring network with an annual average loading of 13 ug/100 sq cm/30 days (micrograms per 100 square centimeters per 30 days). The guideline for flourides of 40 ug/100 sq cm/30 days was not exceeded at Alberta Environment monitoring networks.

Acid Precipitation Monitoring

Precipitation chemistry was monitored, as an accumulation over a one-month period, at 12 locations in the province by Alberta Environment in 1990. The purpose of the network is to monitor the quality of precipitation, detect significant trends of precipitation quality and observe long-range transport of pollutants into the province. Chemical analysis was conducted on precipitation samples to obtain pH, major cations (calcium, ammonium, sodium, magnesium and potassium) and major anions (sulphate, nitrate, chloride and phosphate).

pH

The most acidic (lowest pH) precipitation was recorded at the Fort MacKay (pH of 4.8) and Fort McMurray (pH of 5.0) precipitation stations in 1990. Relatively low annual average pH values were also measured at Beaverlodge, Fort Chipewyan and Kananaskis (pH of 5.2 or less). The least acidic precipitation was deposited at High Prairie, Suffield and Calgary. The Cold Lake and Red Deer precipitation stations recorded annual average pH values close to that of uncontaminated precipitation (pH of 5.6).

Anions (sulphate, nitrate, chloride, phosphate)

Anions are negatively charged ions contained within precipitation which result from acids when parent species react with water vapour. The parent species may be emitted into the atmosphere from coal-fired power plants, oil refineries, gas plants, oil sands plants, pulp and paper plants, fertilizer plants, vehicular emissions and agricultural activities.

A maximum observed wet sulphate deposition rate of 6.9 kg/ha/yr (kilograms per hectare per year) was recorded at Red Deer. Maximum nitrate wet deposition rates were observed at Red Deer (5.3 kg/ha/yr) and Kananaskis (4.8 kg/ha/yr). The highest wet chloride deposition rate was observed at Fort McMurray. Wet phosphate deposition was relatively low at all monitoring stations.

Cations (calcium, ammonium, sodium, magnesium, potassium)

Cations are positively charged ions which are formed when parent species go into solution. Cations may originate from industrial sources such as iron, steel and wood manufacturing, or natural sources such as wind-blown soil and dust.

Wet calcium deposition was a maximum at High Prairie with a value of 2.2 kg/ha/yr. Maximum wet ammonium deposition occurred at Red Deer and Suffield where a value of 2.2 kg/ha/yr was recorded at both stations. Wet potassium and magnesium deposition rates were highest at High Prairie (1.6 and 0.8 kg/ha/yr, respectively) while wet sodium deposition reached at maximum at Fort McMurray (0.7 kg/ha/yr).

ACKNOWLEDGEMENTS

The report that follows details air quality activities that were conducted by Alberta Environment in the province of Alberta during 1990. A great deal of technical expertise is necessary to collect high quality data from such an extensive monitoring program. The dedicated individuals who established and maintained this comprehensive monitoring program are accredited with this accomplishment.

J. Torneby, D. Kupina, D. Bensler, J. Ross, E. Boyko and T. Spackman established and maintained the continuous, intermittent and static monitoring networks. J. Godin was responsible for the operation of the acid precipitation monitoring network. Special acknowledgement is given to R. Brassard and his staff for the continual mechanical upkeep of ambient monitoring equipment. The Alberta Environmental Centre in Vegreville analyzed samples from the intermittent, static and acid precipitation monitoring networks.

TABLE OF CONTENTS

		Page
SUMMARY		iii
ACKNOWLEDGEMENTS		xi
LIST OF FIGURES		xix
LIST OF TABLES		xxi
LIST OF ABBREVIATIONS		xxii
1.	INTRODUCTION	1
2.	AIR QUALITY MONITORING NETWORKS	3
2.1	Continuous Monitoring Network	3
2.2	Intermittent Monitoring Network	6
2.3	Static Monitoring Network	7
2.4	Portable Monitoring Programs	7
2.5	Mobile Monitoring Units	15
2.6	Acid Precipitation Monitoring Network	16
3.	FACTORS AFFECTING AIR POLLUTION DISPERSION	17
3.1	Temperature	17
3.2	Wind	18
3.3	Topography	18
4.	CONTINUOUS MONITORING RESULTS	19
4.1	Index of Air Quality	20
4.1.1	Results	21
4.1.1.1	Edmonton	25
4.1.1.2	Calgary	26
4.1.1.3	Fort Saskatchewan	27
4.1.1.4	Fort McMurray	27
4.2	Wind	27
4.2.1	Results	27
4.2.1.1	Edmonton	28
4.2.1.2	Calgary	28
4.2.1.3	Fort Saskatchewan	28
4.2.1.4	Fort McMurray	28
4.2.1.5	Fort MacKay	31
4.3	Ammonia (NH_3)	31
4.3.1	Characteristics	31
4.3.2	Method of Monitoring	32
4.3.3	Regulations and Guidelines	32
4.3.4	Results	32
4.3.4.1	Fort Saskatchewan	32

TABLE OF CONTENTS (CONT.)

		Page
4.4	Carbon Monoxide (CO)	34
4.4.1	Characteristics	34
4.4.2	Method of Monitoring	34
4.4.3	Regulations and Guidelines	34
4.4.4	Results	35
4.4.4.1	Edmonton	35
4.4.4.2	Calgary	39
4.4.4.3	Fort Saskatchewan	39
4.4.4.4	Fort McMurray	40
4.5	Coefficient of Haze (COH)	40
4.5.1	Characteristics	40
4.5.2	Method of Monitoring	40
4.5.3	Regulations and Guidelines	40
4.5.4	Results	41
4.5.4.1	Edmonton	41
4.5.4.2	Calgary	45
4.5.4.3	Fort Saskatchewan	45
4.5.4.4	Fort McMurray	45
4.6	Hydrogen Sulphide (H_2S)	45
4.6.1	Characteristics	45
4.6.2	Method of Monitoring	46
4.6.3	Regulations and Guidelines	46
4.6.4	Results	46
4.6.4.1	Calgary	49
4.6.4.2	Fort Saskatchewan	49
4.6.4.3	Fort McMurray and Fort MacKay	49
4.7	Oxides of Nitrogen (NO_x)	50
4.7.1	Characteristics	50
4.7.2	Method of Monitoring	51
4.7.3	Regulations and Guidelines	51
4.7.4	Results	51
4.7.4.1	Edmonton	55
4.7.4.2	Calgary	55
4.7.4.3	Fort Saskatchewan	56
4.7.4.4	Fort McMurray	56
4.8	Ozone (O_3)	56
4.8.1	Characteristics	56
4.8.2	Method of Monitoring	57
4.8.3	Regulations and Guidelines	57

TABLE OF CONTENTS (CONT.)

		Page
4.8.4	Results	58
4.8.4.1	Edmonton	58
4.8.4.2	Calgary	62
4.8.4.3	Fort Saskatchewan	62
4.8.4.4	Fort McMurray	63
4.9	Sulphur Dioxide (SO_2)	63
4.9.1	Characteristics	63
4.9.2	Method of Monitoring	64
4.9.3	Regulations and Guidelines	64
4.9.4	Results	64
4.9.4.1	Edmonton	68
4.9.4.2	Calgary	68
4.9.4.3	Fort Saskatchewan	68
4.9.4.4	Fort McMurray and Fort MacKay	68
4.10	Total Hydrocarbons (THC)	68
4.10.1	Characteristics	68
4.10.2	Method of Monitoring	69
4.10.3	Regulations and Guidelines	69
4.10.4	Results	69
4.10.4.1	Edmonton	73
4.10.4.2	Calgary	73
4.10.4.3	Fort Saskatchewan	74
4.10.4.4	Fort McMurray and Fort MacKay	74
5.	INTERMITTENT MONITORING RESULTS	75
5.1	Total Suspended Particulates (TSP)	75
5.1.1	Characteristics	75
5.1.2	Method of Monitoring	75
5.1.3	Regulations and Guidelines	76
5.1.4	Results	76
5.1.4.1	Edmonton	76
5.1.4.2	Calgary	80
5.1.4.3	Fort Saskatchewan and Ellerslie	80
5.2	Benzo (a) Pyrene (BaP)	80
5.2.1	Characteristics	80
5.2.2	Method of Monitoring	81
5.2.3	Regulations and Guidelines	81
5.2.4	Results	81
5.2.4.1	Edmonton	85
5.2.4.2	Calgary	85
5.2.4.3	Fort Saskatchewan and Ellerslie	85

TABLE OF CONTENTS (CONT.)

		Page
5.3	Lead (Pb)	86
5.3.1	Characteristics	86
5.3.2	Method of Monitoring	86
5.3.3	Regulations and Guidelines	86
5.3.4	Results	87
5.3.4.1	Edmonton	87
5.3.4.2	Calgary	87
5.3.4.3	Fort Saskatchewan and Ellerslie	88
5.4	Vinyl Chloride Monomer (VCM)	88
5.4.1	Characteristics	88
5.4.2	Method of Monitoring	88
5.4.3	Regulations and Guidelines	92
5.4.4	Results	92
6.	STATIC MONITORING RESULTS	95
6.1	Total Dustfall	95
6.1.1	Characteristics	95
6.1.2	Method of Monitoring	95
6.1.3	Regulations and Guidelines	95
6.1.4	Results	96
6.2	Calcium	96
6.2.1	Characteristics	96
6.2.2	Method of Monitoring	98
6.2.3	Regulations and Guidelines	99
6.2.4	Results	99
6.3	Total Sulphation	99
6.3.1	Characteristics	99
6.3.2	Method of Monitoring	99
6.3.3	Regulations and Guidelines	101
6.3.4	Results	101
6.3.4.1	One-Month Exposure Period	101
6.3.4.2	Three-Month Exposure Period	104
6.4	Hydrogen Sulphide	104
6.4.1	Characteristics	104
6.4.2	Method of Monitoring	104
6.4.3	Regulations and Guidelines	107
6.4.4	Results	107
6.4.4.1	One-Month Exposure Period	107
6.4.4.2	Three-Month Exposure Period	107

TABLE OF CONTENTS (CONT.)

		Page
6.5	Fluorides	112
6.5.1	Characteristics	112
6.5.2	Method of Monitoring	112
6.5.3	Regulations and Guidelines	112
6.5.4	Results	112
7.	ACID PRECIPITATION MONITORING RESULTS	115
7.1	Characteristics	115
7.2	Method of Monitoring	115
7.3	Regulations and Guidelines	115
7.4	Results	116
7.4.1	pH	116
7.4.2	Anions (sulphate,nitrate,chloride,phosphate)	119
7.4.3	Cations (calcium,ammonium,sodium,magnesium,potassium)	120
8.	REFERENCES	121

LIST OF FIGURES

		Page
Figure 2-1	Location of continuous and intermittent air quality monitoring stations	5
Figure 2-2	Location of static monitoring networks and acid precipitation monitoring stations	8
Figure 4-1	Annual frequency distribution of the IQUA category and the pollutants that contribute to the IQUA for 1990	22
Figure 4-2	Monthly frequency distribution of the IQUA category	23
Figure 4-3	Monthly frequency distribution of pollutants contributing to the IQUA	24
Figure 4-4	Frequency distribution of wind direction at Edmonton and Calgary monitoring locations	29
Figure 4-5	Frequency distribution of wind direction at Fort Saskatchewan and Fort MacKay monitoring locations	30
Figure 4-6	Frequency distribution of ammonia concentrations at Fort Saskatchewan	33
Figure 4-7	Frequency distribution of carbon monoxide concentrations at Edmonton	36
Figure 4-8	Frequency distribution of carbon monoxide concentrations at Calgary	37
Figure 4-9	Frequency distribution of carbon monoxide concentrations at Fort Saskatchewan and Fort McMurray	38
Figure 4-10	Frequency distribution of the coefficient of haze at Edmonton	42
Figure 4-11	Frequency distribution of the coefficient of haze at Calgary	43
Figure 4-12	Frequency distribution of the coefficient of haze at Fort Saskatchewan and Fort McMurray	44
Figure 4-13	Frequency distribution of hydrogen sulphide concentrations at Calgary	47
Figure 4-14	Frequency distribution of hydrogen sulphide concentrations at Fort Saskatchewan, Fort McMurray and Fort MacKay	48
Figure 4-15	Frequency distribution of nitrogen dioxide concentrations at Edmonton	52
Figure 4-16	Frequency distribution of nitrogen dioxide concentrations at Calgary	53
Figure 4-17	Frequency distribution of nitrogen dioxide concentrations at Fort Saskatchewan and Fort McMurray	54
Figure 4-18	Frequency distribution of ozone concentrations at Edmonton	59
Figure 4-19	Frequency distribution of ozone concentrations at Calgary	60
Figure 4-20	Frequency distribution of ozone concentrations at Fort McMurray and Fort Saskatchewan	61
Figure 4-21	Frequency distribution of sulphur dioxide concentrations at Edmonton	65

LIST OF FIGURES (CONT.)

		Page
Figure 4-22	Frequency distribution of sulphur dioxide concentrations at Calgary	66
Figure 4-23	Frequency distribution of sulphur dioxide concentrations at Fort Saskatchewan, Fort McMurray and Fort MacKay	67
Figure 4-24	Frequency distribution of total hydrocarbon concentrations at Edmonton	70
Figure 4-25	Frequency distribution of total hydrocarbon concentrations at Calgary	71
Figure 4-26	Frequency distribution of total hydrocarbon concentrations at Fort Saskatchewan, Fort McMurray and Fort MacKay	72
Figure 5-1	Total suspended particulate loadings at Edmonton	77
Figure 5-2	Total suspended particulate loadings at Calgary	78
Figure 5-3	Total suspended particulate loadings at Fort Saskatchewan and Ellerslie	79
Figure 5-4	Benzo (a) Pyrene loadings at Edmonton	82
Figure 5-5	Benzo (a) Pyrene loadings at Calgary	83
Figure 5-6	Benzo (a) Pyrene loadings at Fort Saskatchewan and Ellerslie	84
Figure 5-7	Lead loadings at Edmonton	89
Figure 5-8	Lead loadings at Calgary	90
Figure 5-9	Lead loadings at Fort Saskatchewan and Ellerslie	91
Figure 5-10	Vinyl chloride monomer concentrations in the Fort Saskatchewan region	93
Figure 6-1	Location of total dustfall monitoring networks	97
Figure 6-2	Location of calcium monitoring networks	100
Figure 6-3	Location of total sulphation monitoring networks (one-month monitoring period)	102
Figure 6-4	Location of total sulphation monitoring networks (three-month monitoring period)	105
Figure 6-5	Location of hydrogen sulphide monitoring networks (one-month monitoring period)	108
Figure 6-6	Location of hydrogen sulphide monitoring networks (three-month monitoring period)	110
Figure 6-7	Location of fluoride monitoring networks	113
Figure 7-1	Location of acid precipitation monitoring stations	117

LIST OF TABLES

		Page
Table 2.1	Pollutants monitored continuously at Alberta Environment monitoring stations	4
Table 2.2	Location of continuous monitoring stations	6
Table 2.3	Location of networks where total dustfall is monitored on a static basis	9
Table 2.4	Location of networks where calcium is monitored on a static basis	9
Table 2.5	Location of networks where hydrogen sulphide is monitored on a static basis	10
Table 2.6	Location of networks where total sulphation is monitored on a static basis	12
Table 2.7	Location of networks where fluorides are monitored on a static basis	14
Table 2.8	Mobile monitoring activities conducted by Alberta Environment	15
Table 4.1	Definition of IQUA rating categories	21
Table 6.1	Averages and exceedances from networks which monitor total dustfall	98
Table 6.2	Averages and maximums from networks which monitor calcium	101
Table 6.3	Averages and exceedances from networks which monitor total sulphation on a one-month exposure basis	103
Table 6.4	Averages and exceedances from networks which monitor total sulphation on a three-month exposure basis	106
Table 6.5	Averages and exceedances from networks which monitor hydrogen sulphide on a one-month exposure basis	109
Table 6.6	Averages and exceedances from networks which monitor hydrogen sulphide on a three-month exposure basis	111
Table 6.7	Averages and exceedances from networks which monitor fluorides	114
Table 7.1	pH and wet deposition rates for anions and cations at acid precipitation monitoring stations	118

LIST OF ABBREVIATIONS

IQUA	- Index of the Quality of the Air
NH_3	- ammonia
CO	- carbon monoxide
COH	- coefficient of haze
H_2S	- hydrogen sulphide
NO_2	- nitrogen dioxide
NO	- nitric oxide
NO_x	- oxides of nitrogen
N_2O	- nitrous oxide
O_3	- ozone
SO_2	- sulphur dioxide
THC	- total hydrocarbons
TSP	- total suspended particulates
BaP	- Benzo (a) Pyrene
Pb	- lead
VCM	- vinyl chloride monomer
VOC	- volatile organic compound
$SO_4^=$	- sulphate ion
NO_3^-	- nitrate ion
NH_4^+	- ammonium ion
Cl^-	- chloride ion
$PO_4^=$	- phosphate ion
Na^+	- sodium ion
K^+	- potassium ion
Ca^{++}	- calcium ion
Mg^{++}	- magnesium ion
ppm	- parts per million by volume
ppb	- parts per billion by volume
ug/m^3	- micrograms per cubic meter
kg/ha/yr	- kilograms per hectare per year
NAPS	- National Air Pollution Surveillance
SSI	- selective size inlet

mg/100 sq cm/30 days - milligrams per 100 square centimeters per 30 days
ug/100 sq cm/30 days - micrograms per 100 square centimeters per 30 days
mg SO_3 equivalent/day/100 sq cm - milligrams expressed as sulphite per day per 100 square centimeters

1. INTRODUCTION

Air quality is an issue which has received increased attention over the past decade. Alberta Environment recognizes that the quality of the environment is affected by the quality of the air, water and soil. The Environmental Quality Monitoring Branch of Alberta Environment has the responsibility of monitoring and reporting ambient air quality. When applicable, air quality is compared to established regulations and guidelines.

The Environmental Quality Monitoring Branch operates a comprehensive air quality monitoring program consisting of continuous, intermittent, static, mobile, portable and acid precipitation monitoring networks. The objectives of this air quality monitoring program are to:

- provide data for the assessment of existing air quality relative to regulations and objectives;
- report long-term trends in air quality;
- inform the public on the status of air quality; and
- undertake monitoring in special problem areas.

This report documents and analyzes air quality data for 1990 from January 1 to December 31. When exceedances of the regulations or guidelines occur, an attempt is made to relate the exceedances to wind direction so that the source or sources of the pollutant may be identified. Long-term trends of pollutant concentrations are also presented and an explanation of these trends is included.

Air quality instrumentation and data are subject to a stringent quality control and quality assurance program. Instrument calibration and data collection procedures are detailed in the Alberta Environment Air Monitoring Directive (Alberta Environment 1989). After the data has been collected, monthly quality control is conducted by a technologist to ensure that the data presented in monthly and annual reports is certified as being correct. If the quality of the data is questionable, it is deleted from monthly and annual reports.

Detailed analyses of data collected by continuous, intermittent, static and acid precipitation monitoring networks that are operated by Alberta Environment are presented in this report. Information collected by portable and mobile monitoring programs are summarized in this report. The data used to generate this report are detailed in a separate document entitled "Air Quality Monitoring Data Summary for Alberta: 1990".

2. AIR QUALITY MONITORING NETWORKS

2.1 CONTINUOUS MONITORING NETWORK

Air pollutants are monitored on a continuous basis at nine locations in Alberta. Three continuous monitoring stations are located in each of Calgary and Edmonton. Additional stations are located in Fort Saskatchewan, Fort McMurray and Fort MacKay. Each continuous monitoring unit is equipped to monitor various air quality and meteorological parameters on an hourly basis. These parameters are listed in Table 2.1. The locations of continuous monitoring stations are presented in Figure 2-1 and Table 2.2.

The Edmonton and Calgary stations are designated according to the general location of the stations in the downtown, residential and industrial areas of the city. All Edmonton and Calgary air quality stations are equipped to monitor ambient concentrations of carbon monoxide (CO), oxides of nitrogen (including NO and NO_2), ozone (O_3), total hydrocarbons (THC) and coefficient of haze (COH). In addition, the Edmonton industrial monitoring unit monitors sulphur dioxide (SO_2) and the Calgary industrial monitoring unit monitors sulphur dioxide and hydrogen sulphide (H_2S). With the exception of the Edmonton and Calgary downtown locations, all stations monitor wind speed and direction.

The continuous monitoring unit located in Fort Saskatchewan monitors for the same pollutants as the Calgary industrial monitoring station (i.e., CO, NO_x, NO, NO_2, O_3, THC, COH, SO_2 and H_2S) with the addition of ammonia (NH_3).

The Fort McMurray monitoring station measures the same pollutants as the Calgary industrial monitoring unit. Only SO_2, H_2S and THC are monitored at the Fort MacKay monitoring station.

Table 2.1 **Pollutants monitored continuously at Alberta Environment monitoring stations.**

Monitoring Station	Parameter								
	NH_3	CO	COH	H_2S	NO_x[a]	O_3	SO_2	THC	Wind
Edmonton Downtown		X	X		X	X		X	
Edmonton Residential		X	X		X	X		X	X
Edmonton Industrial		X	X		X	X	X	X	X
Calgary Downtown		X	X		X	X		X	
Calgary Residential		X	X		X	X		X	X
Calgary Industrial		X	X	X	X	X	X	X	X
Fort Saskatchewan	X	X	X	X	X	X	X	X	X
Fort McMurray		X	X	X	X	X	X	X	X
Fort MacKay				X			X	X	X

[a] includes NO_2 and NO

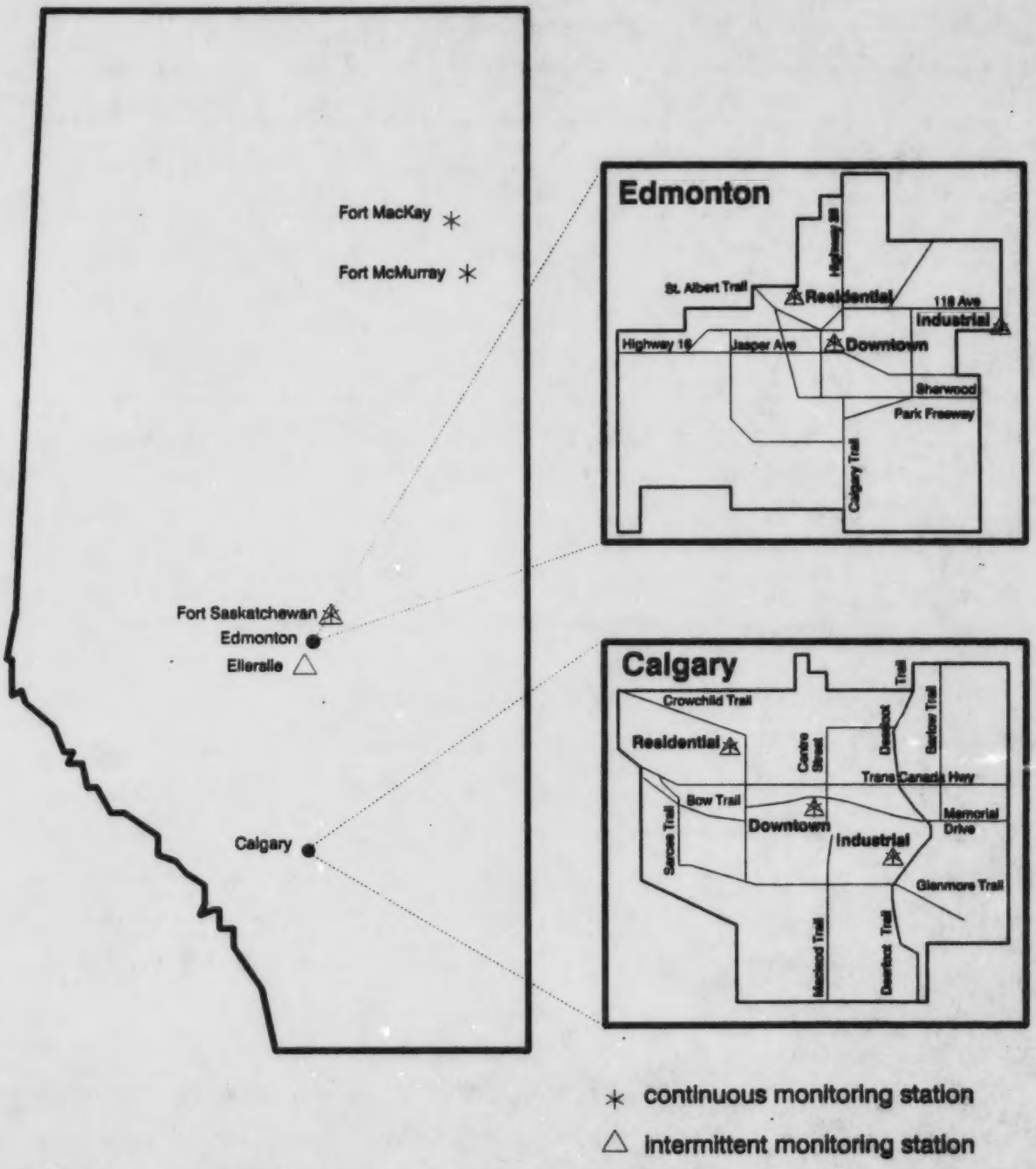

Figure 2-1 Location of continuous and intermittent air quality monitoring stations.

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Table 2.2 Location of continuous monitoring stations.

Station Name	Station Location
Edmonton Downtown Monitoring Unit (EDMU)	10255 - 104 St.
Edmonton Residential Monitoring Unit (ERMU)	13335 - 127 St.
Edmonton Industrial Monitoring Unit (EIMU)	105 Ave. and 17 St.
Calgary Downtown Monitoring Unit (CDMU)	611 - 4 St. S.W.
Calgary Residential Monitoring Unit (CRMU)	39 St. and 29 Ave. N.W.
Calgary Industrial Monitoring Unit (CIMU)	49 Ave. and 15 St. S.E.
Fort Saskatchewan Monitoring Unit (EMMU)	100 Ave. and 98 St.
Fort McMurray Monitoring Unit (FMMU)	Franklin Ave. at old waterpump house site
Fort MacKay Monitoring Unit (FRMU)	100 m west of the Fort MacKay Band Council Administration Office

2.2 INTERMITTENT MONITORING NETWORK

Suspended particulates are monitored, as a 24-hour accumulated loading, at each of the Edmonton and Calgary continuous monitoring locations as well as at Fort Saskatchewan and Ellerslie (refer to Figure 2-1). Suspended particulate samples are collected by high-volume samplers and subsequently submitted for laboratory analysis to quantify loadings of total suspended particulates (TSP). Suspended particulates are monitored on every sixth day according to the National Air Pollution Surveillance (NAPS) schedule.

In addition to suspended particulates monitored by high-volume samplers, Alberta Environment also operates two dichotomous samplers and one selective size inlet (SSI) sampler in the province. The dichotomous samplers are located at the Edmonton and Calgary downtown continuous monitoring locations while the SSI sampler is situated at the Edmonton downtown continuous monitoring station. The dichotomous sampler separates particulates into two size fractions; fine (less than 2.5 microns in diameter) and coarse

(2.5 to 10 microns in diameter) (a human hair is about 100 microns in diameter) while the SSI sampler collects all particulates with a diameter less than 10 microns. The monitoring frequency of the dichotomous and SSI instruments conforms to the NAPS network schedule (i.e., every sixth day). These monitoring programs are conducted in cooperation with Environment Canada.

In October of 1990, volatile organic compound (VOC) monitoring was initiated at the Edmonton industrial and Calgary downtown stations. VOCs are also monitored every sixth day in accordance with the NAPS schedule. Analysis of the samples and interpretation of the data is undertaken by Environment Canada.

In 1990, vinyl chloride monomer (VCM) was monitored at three sites in the Fort Saskatchewan region because of the town's proximity to chemical processing plants. These sites are located at the Fort Saskatchewan continuous monitoring location, west of the Diamond Shamrock petrochemical processing plant (now known as the BF Goodrich petrochemical processing plant) and west of the Dow Chemical petrochemical processing plant.

2.3 STATIC MONITORING NETWORK

Static monitoring is the measurement of total accumulations of pollutant loadings over a specified time period. This time period is either one-month or three-months in duration. Total sulphation, hydrogen sulphide, total dustfall, fluorides and calcium are monitored on a static basis. Approximately 70 static monitoring networks are administered by Alberta Environment in the province. Figure 2-2 shows static monitoring network locations. Network locations and number of monitoring stations per network are indicated in Tables 2.3 to 2.7.

2.4 PORTABLE MONITORING PROGRAMS

Portable monitoring programs are air monitoring projects that are initiated on the basis of public complaints, requests by municipal officials or for special projects. In 1990, portable monitoring programs were conducted in Medicine Hat, Drayton Valley and the Fort Saskatchewan region.

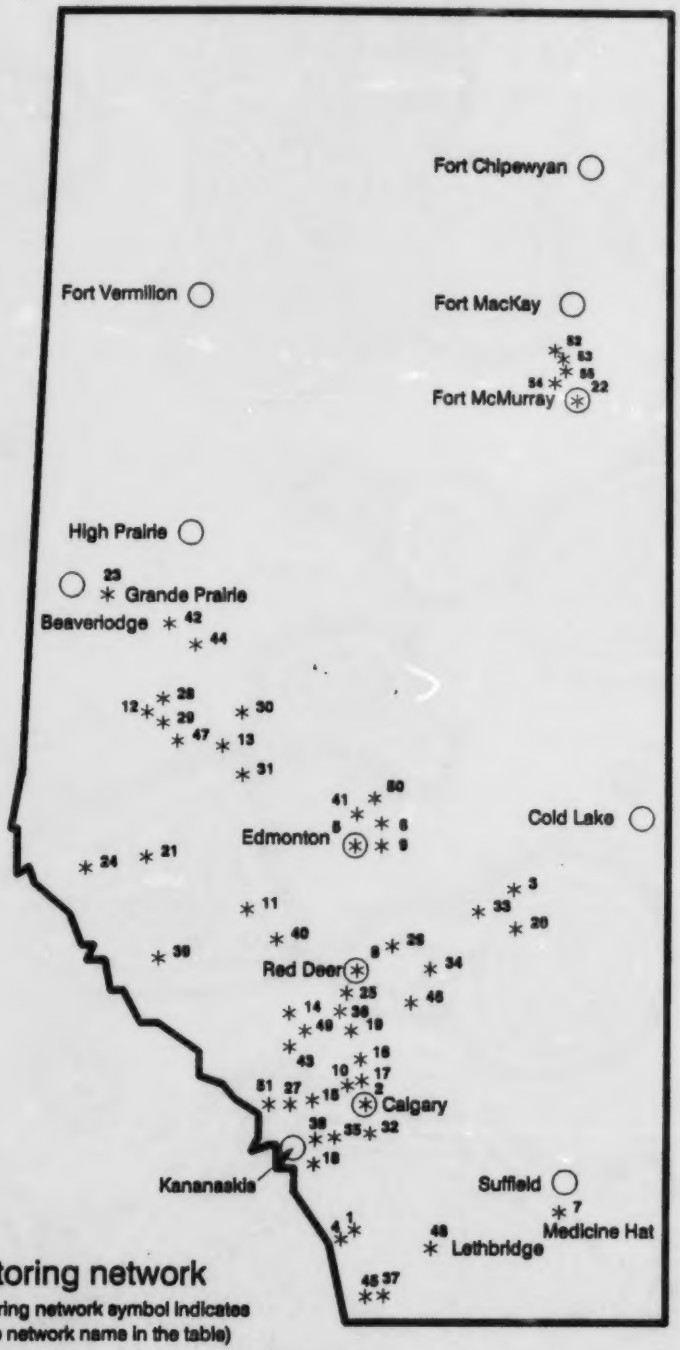

Figure 2-2 Location of static monitoring networks and acid precipitation monitoring stations.

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Table 2.3 Location of networks where total dustfall is monitored on a static basis.

Network Location	# of Stations	Monitoring Period	Map Location
Blairmore	2	1 month	1
Calgary	6	1 month	2
Camrose	1	1 month	3
Coleman	12	1 month	4
Edmonton	27	1 month	5
Edmonton Industrial	1	1 month	5
Edmonton Residential	1	1 month	5
Exshaw	5	1 month	51
Fort Saskatchewan (special)	1	1 month	6
Lethbidge	6	1 month	48
Medicine Hat	5	1 month	7
Red Deer	1	1 month	8
Sherwood Park	3	1 month	9

Table 2.4 Location of networks where calcium is monitored on a static basis.

Network Location	# of Stations	Monitoring Period	Map Location
Edmonton	3	1 month	5
Edmonton Industrial	1	1 month	5
Edmonton Residential	1	1 month	5
Exshaw	5	1 month	51

Table 2.5 Location of networks where hydrogen sulphide is monitored on a static basis.

Network Location	# of Stations	Monitoring Period	Map Location
Balzac	4	3 months	10
Bigstone	2	3 months	12
Bitumont Tower	1	1 month	52
Blue Ridge	4	3 months	13
Buck Lake	4	3 months	11
Caroline	2	3 months	14
Carstairs	4	3 months	16
Cochrane	4	3 months	15
Coleman	4	3 months	4
Camrose	1	1 month	3
Crossfield	5	3 months	17
Diamond Valley	4	3 months	18
Didsbury	8	3 months	19
Edburg	1	3 months	20
Edson	4	3 months	21
Ells Tower	1	1 month	53
Fort McMurray	6	1 month	22
Fort Saskatchewan (special)	1	1 month	6
Grande Prairie	1	1 month	23
Hinton	3	1 month	24
Innisfail	4	3 months	25
Joffre	2	1 month	26
Jumping Pound	4	3 months	27
Kaybob	4	3 months	28
Kaybob (south)	4	3 months	29
Lone Pine Creek	5	3 months	30
Mayerthorpe	2	3 months	31
Mazeppa	4	3 months	32

Table 2.5 (cont.) **Location of networks where hydrogen sulphide is monitored on a static basis.**

Network Location	# of Stations	Monitoring Period	Map Location
Muskeg Tower	1	1 month	55
New Norway	1	1 month	33
Nevis	7	3 months	34
Okotoks	5	3 months	35
Olds	4	3 months	36
Pincher Creek	6	3 months	37
Quirk Creek	6	3 months	38
Ram River	5	3 months	39
Red Deer (city)	2	1 month	8
Red Deer	4	3 months	8
Redwater	4	3 months	50
Rimbey	4	3 months	40
Sherwood Park	3	1 month	9
St. Albert	2	1 month	41
Simonette	2	3 months	42
Sundre	2	3 months	43
Thickwood Tower	1	1 month	54
Valleyview	2	3 months	44
Waterton	8	3 months	45
Wimborne	4	3 months	46
Windfall	4	3 months	47

Table 2.6 Location of networks where total sulphation is monitored on a static basis.

Network Location	# of Stations	Monitoring Period	Map Location
Balzac	4	3 months	10
Bigstone	2	3 months	12
Bitumont	1	1 month	52
Blue Ridge	4	3 months	13
Buck Lake	4	3 months	11
Calgary	38	1 month	2
Caroline	2	3 months	14
Carstairs	4	3 months	16
Cochrane	4	3 months	15
Coleman	4	3 months	4
Camrose	1	1 month	3
Crossfield	5	3 months	17
Diamond Valley	4	3 months	18
Didsbury	8	3 months	19
Edburg	1	3 months	20
Edmonton	27	1 month	5
Edmonton Industrial	1	1 month	5
Edmonton Residential	1	1 month	5
Edson	4	3 months	21
Ells Tower	1	1 month	53
Fort McMurray	6	1 month	22
Fort Saskatchewan	4	1 month	6
Fort Saskatchewan (special)	1	1 month	6
Grande Prairie	1	1 month	23
Hinton	3	1 month	24
Innisfail	4	3 months	25
Joffre	2	1 month	26
Jumping Pound	4	3 months	27
Kaybob	4	3 months	28

Table 2.6 (cont.) **Location of networks where total sulphation is monitored on a static basis.**

Network Location	# of Stations	Monitoring Period	Map Location
Kaybob (south)	4	3 months	29
Lethbridge	5	1 month	48
Lone Pine Creek	5	3 months	30
Mayerthorpe	2	3 months	31
Mazeppa	4	3 months	32
Medicine Hat	5	1 month	7
Muskeg Tower	1	1 month	55
New Norway	1	1 month	33
Nevis	7	3 months	34
Okotoks	5	3 months	35
Olds	4	3 months	36
Pincher Creek	6	3 months	37
Quirk Creek	6	3 months	38
Ram River	5	3 months	39
Raven Brood	1	1 month	49
Red Deer (city)	2	1 month	8
Red Deer	4	3 months	8
Redwater	4	3 months	50
Redwater	4	1 month	50
Rimbey	4	3 months	40
Sherwood Park	3	1 month	9
St. Albert	2	1 month	41
Simonette	2	3 months	42
Sundre	2	3 months	43
Thickwood Tower	1	1 month	54
Valleyview	2	3 months	44
Waterton	8	3 months	45
Wimborne	4	3 months	46
Windfall	4	3 months	47

Table 2.7 Location of networks where fluoride is monitored on a static basis.

Network Location	# of Stations	Monitoring Period	Map Location
Fort Saskatchewan	1	1 month	**22**
Medicine Hat	1	1 month	**7**
Redwater	4	1 month	**50**

Air quality monitoring was conducted in Medicine Hat from January 10, 1990 to April 30, 1990. The monitoring station was situated at the Medicine Hat Health Unit located at 770 - 1st Street S.E. The purpose of this study was to assess general air quality over a three-month period in Medicine Hat. The parameters monitored included CO, COH, NO_x, NO, NO_2, O_3 SO_2, THC and suspended particulates (including TSP, BaP and Pb). Results from this monitoring program will be summarized in an independent Alberta Environment report.

Alberta Environment conducted a follow-up suspended particulate monitoring program in Drayton Valley during the fall of 1990. This program was initiated, at the request of the Town of Drayton Valley, in response to concerns voiced by local residents regarding a noticeable amount of wood and ash particulate fallout evident in the region. Suspended particulates were monitored by a network of five high-volume samplers from September 1 to November 29, 1990 and one dichotomous sampler during November, 1990. In addition to suspended particulates, total dustfall was monitored at each high-volume sampler monitoring location. Wind direction and speed data were collected at one high-volume sampler monitoring location during fall of 1990. All high volume samples were analyzed for TSP loading. Selected high volume samples underwent further analysis for particle identification, BaP loading and elemental carbon loading. The results of this project are detailed in an independent report (Alberta Environment 1991).

A meteorological monitoring program commenced near the Town of Fort Saskatchewan in April 1988. The program is expected to be complete at the end of April 1991. The objectives of this project are to: (1) specify the diffusion climatology for the Fort Saskatchewan area; (2) make meteorological interpretations of high pollution episodes in the Fort Saskatchewan area; (3) provide high quality input data for dispersion models; and

(4) determine differences in the air pollution potential between the Ellerslie and Fort Saskatchewan regions. A report summarizing the conclusions of this study is expected after the termination of the project.

2.5 MOBILE MONITORING UNITS

Alberta Environment operates four modified suburban trucks, equipped with H_2S and SO_2 monitors. One of these vehicles is also equipped to monitor THC. Alberta Environment also operates a self-contained mobile laboratory that is equipped to monitor for CO, COH, H_2S, NO_x, NO, NO_2, O_3, SO_2 and THC. This mobile laboratory also contains a gas chromatograph unit. Mobile monitoring surveys conducted in 1990 are summarized in Table 2.8.

Table 2.8 Mobile monitoring activities conducted by Alberta Environment in 1990.

Monitoring Survey	Survey Date	Survey Objectives	Parameters Monitored
Truck unloading terminal at Warburg	Feb 9	Measure suphur releases during unloading operations in response to odour complaint.	SO_2, H_2S
Sunpine Forest Products wood chip fire near Sundre	Feb 22, 23, 26, 27, 28 and Mar 1	Measure impact of smoke plume in the area.	CO, THC, NO_x, SO_2
Sturgeon Regional Landfill near Morinville	Jul 10	Determine levels from landfill and chemical storage operations.	CO, NO, NO_2, NO_x, O_3, SO_2, H_2S, THC
New Alta warehouse fire near Fort Saskatchewan	July 26 and 27	Measure emissions from burning of warehouse and possibly hazardous contents.	CO, NO, NO_2, NO_x, O_3, SO_2, H_2S, THC
Suncor Plant shutdown and startup near Fort McMurray	May 18 to 24; May 28 and 29; June 29; July 3 and 4; and Sept. 24 to 28	Measure emission levels from Suncor during Plant shutdown and startup phases.	CO, NO, NO_2, NO_x, O_3, SO_2, H_2S, THC

2.6 ACID PRECIPITATION MONITORING NETWORK

Precipitation chemistry is monitored, on a one-month basis, at 12 locations in the province by Alberta Environment. The locations of acid precipitation monitoring stations are indicated in Figure 2-2. Precipitation chemistry samples are also collected at the High Prairie station on a daily basis. Laboratory analysis is conducted on precipitation samples to obtain the following parameters:

- pH;
- strong acidity;
- total acidity;
- specific conductance;
- sulphate (dissolved) as $SO_4^{=}$;
- nitrate as NO_3^{-};
- ammonia as NH_4^{+};
- chloride (dissolved) as Cl^{-};
- ortho phosphate as $PO_4^{=}$;
- sodium as Na^{+};
- potassium as K^{+};
- calcium as Ca^{++} (dissolved); and
- magnesium as Mg^{++} (dissolved).

3. FACTORS AFFECTING AIR POLLUTION DISPERSION

The quality of the air is dependent on the quantity of pollutants emitted into the atmosphere and the ability of the atmosphere to disperse the pollutants. Air pollution transport and dispersion is influenced by the temperature structure of the atmosphere, turbulence in the atmosphere, wind direction and wind speed, and the changes in these elements introduced by local topography.

3.1 TURBULENCE

When the earth's surface is heated by the sun, pockets of warm air will form near the ground. This less dense, warm air will rise from ground-level to be replaced by cooler air. The cooler air is, in turn, heated and thus ascends creating convective turbulence. This vertical motion in the atmosphere becomes more intense as solar heating increases. Convective turbulence causes vigorous atmospheric mixing which allows air pollutants to disperse rapidly. During daylight hours, when winds are light to moderate, atmospheric overturning, or convection, is the dominant mechanism for pollutant dispersion.

Under high wind speeds, the frictional force of air movement over the ground will create mechanical turbulence. The greater the wind speed, the more mechanical turbulence that is generated. Mechanical turbulence is the dominant mechanism for atmospheric mixing on windy days and at night when convective mixing is negligible.

3.2 TEMPERATURE STRUCTURE

The temperature in the lower atmosphere may increase or decrease with height depending on the amount of energy received from the sun. As evening approaches, the ground experiences a net heat loss to the atmosphere. As the ground cools, the lower levels of the atmosphere will also cool. The vertical temperature profile is now the reverse of the daytime situation; i.e., temperature increases with height. Heat loss from the earth's surface causes a temperature inversion which will limit plume rise from pollution sources. Temperature inversions are common in the winter when heat from the sun is minimal. The persistence of temperature inversions over a long period of time will lead to increased concentrations of air pollutants in the lower atmosphere.

When solar heating or heating from man-made sources (e.g. the urban heat island) is strong enough, a shallow well-mixed layer will develop near the ground. This layer, which may be "capped" by a temperature inversion aloft, is known as the mixing layer. The depth of the mixing layer defines the volume of air in which air pollutants can be mixed. The lower the depth of the mixing layer, the less volume that is available to disperse air pollutants. A persistent lack of a mixing layer or a shallow mixing depth may lead to high air pollution episodes. The mixing layer is especially important in urban locations where large quantities of pollutants are released near ground level.

3.3 WIND

Wind direction and wind speed will determine the trajectory, or path, of air pollutants from source to receptor. Mechanical turbulence created by high wind speeds will enable more rapid dispersion of air pollutants released near ground-level. Air pollution emitted by elevated stack sources may actually be transported more rapidly to the ground and, therefore, lead to higher ground-level pollutant concentrations.

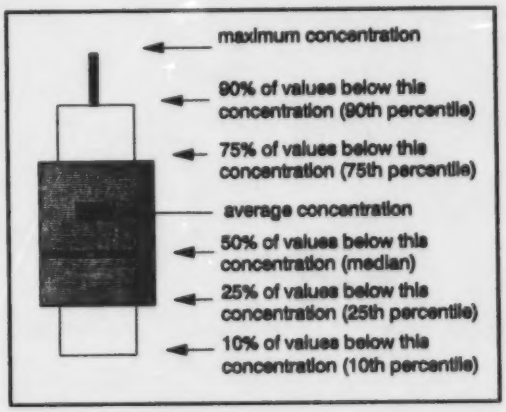
3.4 TOPOGRAPHY

The structure and orientation of terrain features will often influence and even control air motion and mechanical turbulence in the lower atmosphere. Small hills and trees may alter wind speed and direction while also enhancing mechanical turbulence. Larger terrain features such a mountains, hills and valleys may be a governing factor in the control of wind speed and wind direction. For example, wind may be diverted around large hills and mountains and channelled through valleys. Important diurnal variations of wind may also be caused by terrain features. A common cause for high pollution episodes is the occurrence of a persistant temperature inversion in a valley which contains numerous pollutant sources.

4. CONTINUOUS MONITORING RESULTS

Data analysis has been conducted on all parameters which are monitored continuously by Alberta Environment. A summary of the results of individual parameters collected by the continuous air quality network is preceded by a discussion of the Index of the Quality of the Air.

Concentrations of individual pollutants are summarized, on a monthly basis, in diagrams referred to as percentile diagrams or frequency distribution diagrams. An explanation of these diagrams is presented below:


maximum concentration
90% of values below this concentration (90th percentile)
75% of values below this concentration (75th percentile)
average concentration
50% of values below this concentration (median)
25% of values below this concentration (25th percentile)
10% of values below this concentration (10th percentile)

Analysis of trends of continuously monitored parameters is presented when at least four years of historical data are available. Trend analysis was conducted through the application of Daniel's Trend Test (U.S. Environmental Protection Agency 1974; World Health Organization 1980). This is a non-parametric sign-rank test which ranks observations from lowest to highest and compares the rank to the chronological order of the observations. From this, a value of the Spearman Rank Correlation Coefficient may be obtained. A trend is considered significant if the probability of the trend being correct is 95% or greater; that is a 95% level of confidence has been established.

4.1 INDEX OF THE QUALITY OF THE AIR

The Index of the QUality of the Air (IQUA) is a system that has been developed to report ambient concentrations of specific pollutants in a manner that can be easily understood by the general public. The IQUA was developed by a federal-provincial committee in 1978 and adopted by Alberta Environment in December of 1979.

One way to describe the quality of the air is to report the concentrations of each pollutant. However, this can be confusing and make interpretation difficult because each pollutant has different potential effects at different concentrations. The IQUA relates the effects of different pollutants to a common scale which may be easily understood by the general public.

The IQUA converts the measurements of five major pollutants (SO_2, O_3, CO, the COH, and NO_2) to a single rating and corresponding air quality description. An IQUA rating of 1 to 25 indicates Good air quality; 26 to 50 is Fair air quality; 51 to 100 is Poor air quality; and an IQUA rating greater than 100 indicates Very Poor air quality. For example, a rating of 30 (Fair) for two individual pollutants indicates the same degree of environmental impact for each individual pollutant. The specific effects themselves, however, will vary according to the pollutant.

With the exception of the COH, the air pollutant concentrations are linked to regulations under Alberta's Clean Air Act and the National Air Quality Objectives. These regulations and objectives consider the effects of different pollutants on human health, animals, vegetation, or general concerns such as odour and visibility. The IQUA rating categories are defined in the Table 4.1.

The IQUA for Edmonton and Calgary is available to the Alberta public and media twice each weekday. Recordings of the index are issued at 8:15 a.m. and 15:15 p.m., Monday through Friday in both cities. The index telephone number is 427-7273 in Edmonton and 250-2099 in Calgary. A total of 1744 calls were received by the IQUA telephone number at Edmonton in 1990. The highest frequency of calls was on March 5 when 37 calls were received. The IQUA on this day in Edmonton was Fair due to NO_2 (downtown) and the coefficient of haze (visible dust and smoke in the atmosphere at residential monitoring site).

Table 4.1 Definition of IQUA rating categories.

IQUA rating	Frequency in Alberta	Effects
Good	almost all the time	Desirable range: no known harmful effects to soil, water, vegetation, animals, materials, visibility or human health. The long-term goal for air quality in Canada is to be in this range all the time.
Fair	occasional (typical when weather conditions inhibit pollutant dispersion)	Acceptable range: adequate protection against harmful effects to soil, water, vegetation, animals, materials, visibility and human health.
Poor	very seldom	Tolerable range: not all aspects of the environment are adequately protected from possible adverse effects. Long-term control action may be necessary, depending on the frequency, duration and circumstances of the readings.
Very Poor	very rare	Intolerable range: at this range, further deterioration of air quality and continued high readings could pose a risk to public health.

Source: Environment Canada (1980).

4.1.1 Results

The IQUA is calculated each hour and is summarized in monthly data reports for all Edmonton, Calgary, Fort Saskatchewan and Fort McMurray continuous air quality monitoring stations. At Fort MacKay, only SO_2, H_2S and THC are monitored on a continuous basis, therefore, the IQUA is not calculated. A summary of the frequency of the IQUA categories and the contribution of each pollutant to the IQUA category is presented for each monitoring station in Figure 4-1. A monthly frequency distribution of the IQUA category and pollutants that contribute to the IQUA category are illustrated in Figures 4-2 and 4-3, respectively.

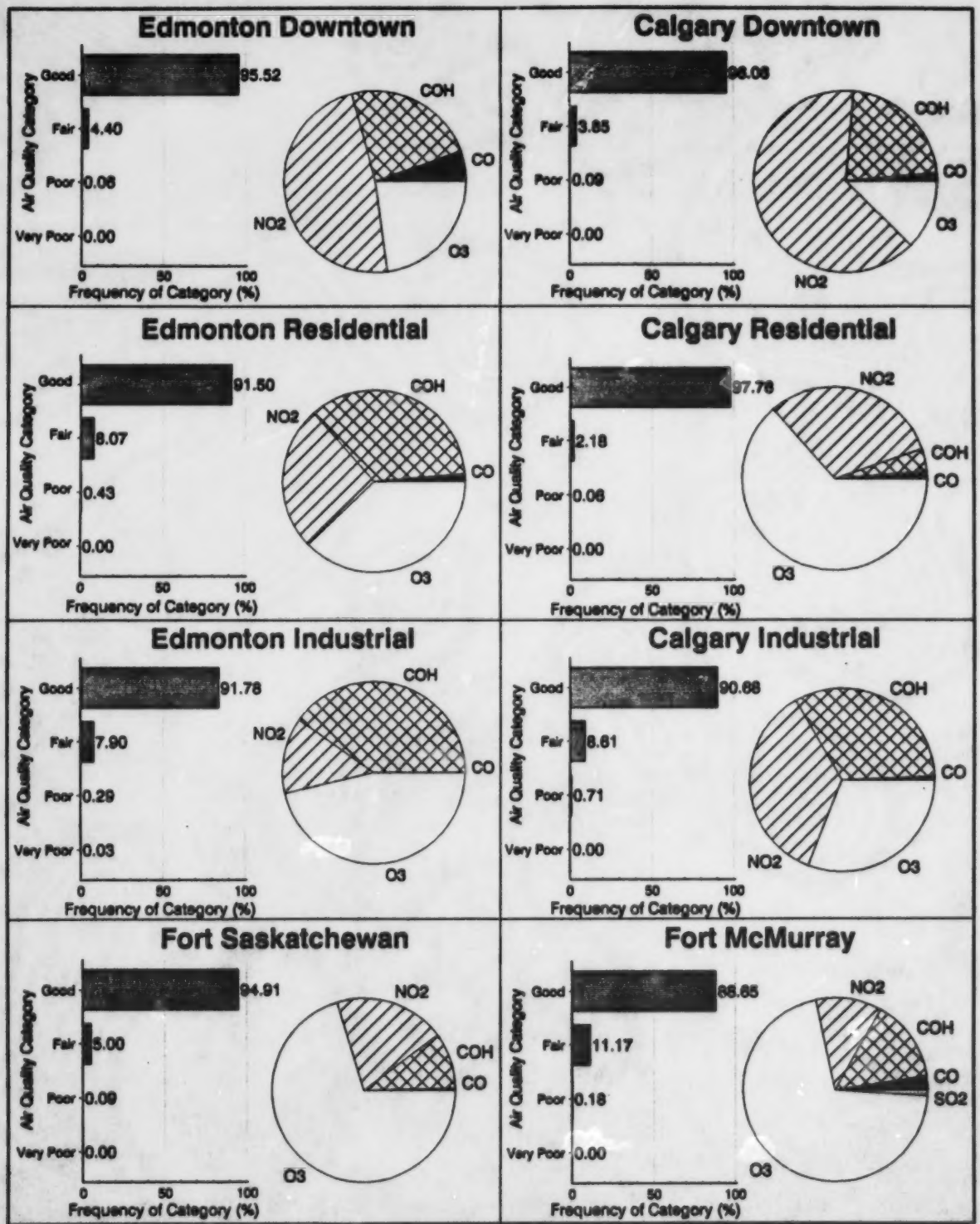


Figure 4-1 Annual frequency distribution of the IQUA category and the pollutants that contribute to the IQUA for 1990.

Edmonton 427-7273
Calgary 250-2099

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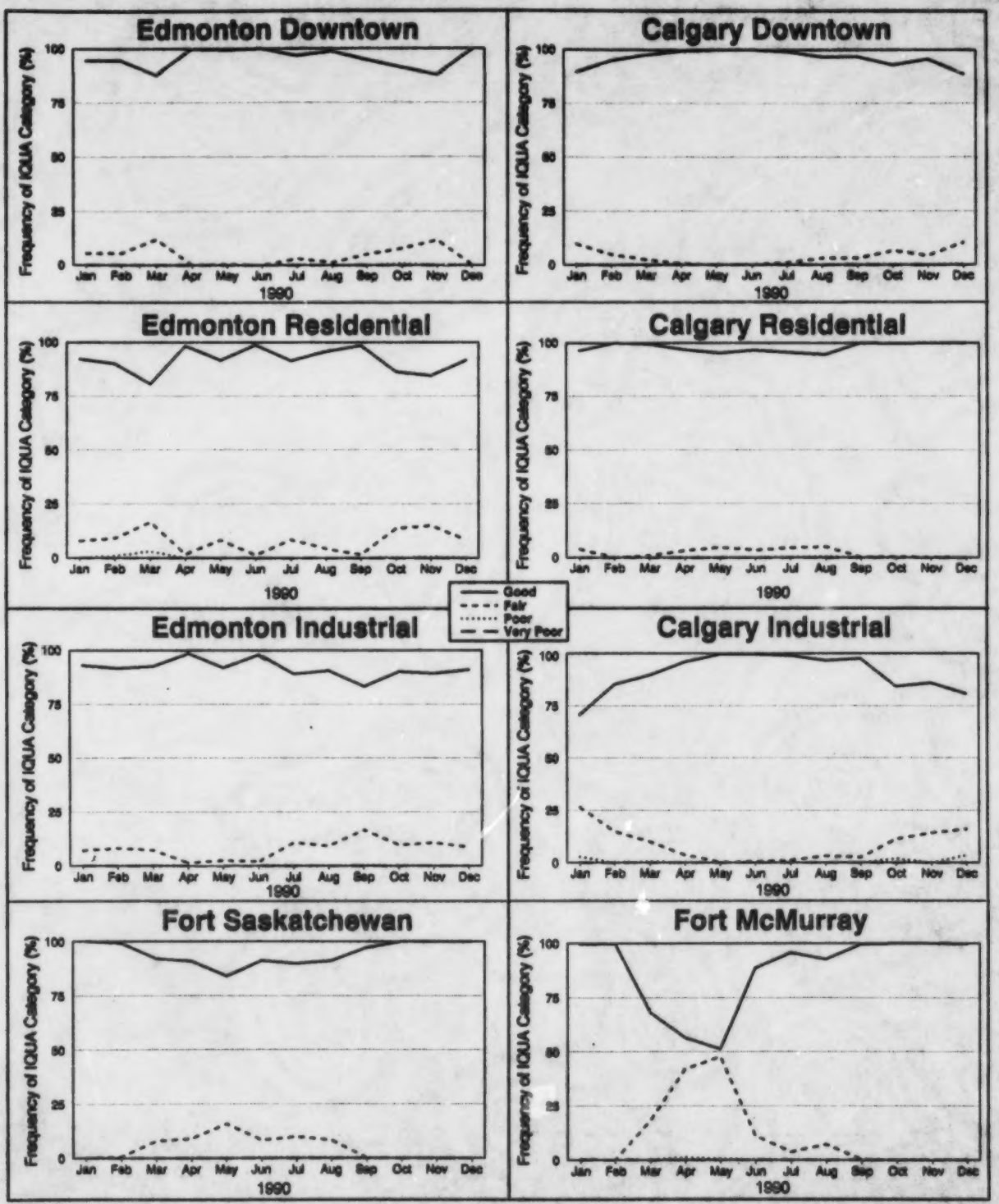

Figure 4-2 Monthly frequency distribution of the IQUA category.

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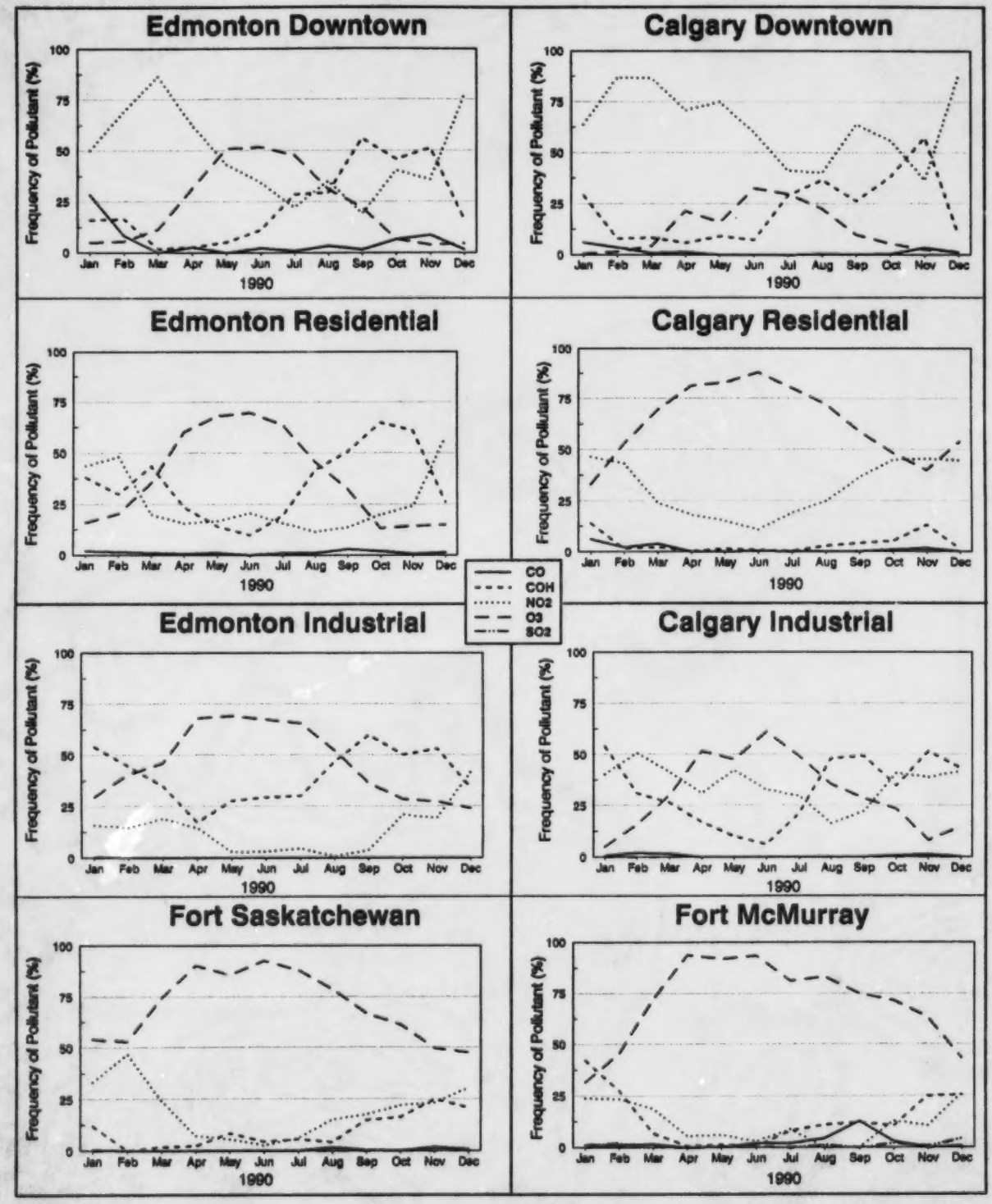

Figure 4-3 Monthly frequency distribution of pollutants contributing to the IQUA category.

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At all monitoring stations, the IQUA was Good for the vast majority of time. On an annual basis, the frequency of IQUA ratings in the Good category ranged from 89% at the Fort McMurray monitoring station to 98% at the Calgary residential monitoring location. The Calgary residential monitoring station also recorded the lowest frequency of Fair air quality ratings (2%) while the highest frequency of Fair ratings was reported at the Fort McMurray monitoring location (11%). The IQUA readings were in the Poor category less than 1% at all locations. The highest frequency of Poor air quality ratings was reported at the Calgary industrial monitoring location. Very Poor air quality ratings were recorded for 0.03% of the time (three hours) at the Edmonton industrial station.

The pollutants responsible for the IQUA ratings are largely dependent on the location of the air quality station in relation to the source or sources. At locations where vehicle emissions were the predominant pollutant sources, NO_2, CO and the COH comprised the IQUA although, O_3 also contributed to the IQUA rating at these locations. At stations not situated near high traffic areas, O_3 was the most common pollutant. The majority of Poor air quality ratings at urban monitoring stations were attributed to the COH, which is an indicator of the amount of dust and smoke in the atmosphere. Poor air quality ratings at air quality stations located away from major traffic arteries were largely infuenced by O_3.

4.1.1.1 Edmonton

The highest frequency of Good air quality ratings was evident during the spring and summer at the Edmonton downtown and residential monitoring stations and during the spring at the industrial monitoring location. A high frequency Good IQUA ratings (over 90%) were also observed in the winter months of December and January at all Edmonton monitoring stations. Fair air quality ratings were most frequent in the late fall and early spring seasons at the downtown and residential monitoring stations. The highest frequency of Fair IQUA ratings at the industrial location were evident in the summer and fall. The higher frequency of Fair and Poor IQUA ratings in the spring and summer at the industrial monitoring station reflect the contribution of O_3 to the IQUA rating at this less-urban location. Very Poor air quality ratings were reported for three hours at the industrial monitoring station on May 25 due to a dust storm which transported dust from agricultural

fields east of Edmonton. The COH readings were very high for this three hour period. On the following day, May 26, the IQUA category was in the Poor category for the majority of the day due to resultant dust in the air from the dust storm.

At the Edmonton downtown and residential monitoring stations, NO_2 was the major contributor to the IQUA rating in the winter and early spring. O_3 was the primary pollutant from April through August. The COH was the major pollutant in the fall at the downtown and residential monitoring stations. CO was responsible for almost 30% of IQUA ratings in January at the downtown monitoring station. The major pollutants which contributed to air quality ratings at the industrial monitoring location were COH (fall and winter) and O_3 (spring and summer). Significant contributions of NO_2 to the IQUA rating in the fall and winter at the Edmonton industrial monitoring location are noted.

4.1.1.2 Calgary

Good air quality was evident almost 90% of the time in every month at Calgary downtown and residential monitoring locations. At the industrial monitoring location the IQUA was in the Good category at least 90% of the time from April to September. Fair air quality was most common in the fall and winter at the downtown and industrial monitoring locations. The IQUA was most frequently in the Fair category during the spring and summer at the Calgary residential monitoring location. This reflects the contribution of O_3 to air quality ratings at the residential location. A low frequency of Poor air quality ratings are indicated in the fall and winter at the downtown and industrial monitoring locations and summer at the residential location.

Poor ratings at the downtown and industrial locations are predominantly due to the COH while poor ratings at the residential monitoring location are due to O_3. NO_2 and the COH are the major pollutants during the fall and winter at the Calgary downtown and industrial monitoring sites. O_3 becomes the most common pollutant at these locations in the spring and summer. A high frequency of IQUA ratings are due to O_3 in all months at the residential monitoring location with O_3 becoming the dominant pollutant which contributes to the IQUA rating in the spring and summer. The IQUA ratings were also influenced substantially by NO_2 during the fall and winter at the Calgary residential monitoring station.

4.1.1.3 *Fort Saskatchewan*

The air quality index was in the Good category over 90% of the time during all months with the exception of May and July at the Fort Saskatchewan monitoring unit. The lowest frequency of Good air quality ratings was in May when 84% of the ratings were in the Good category. Fair air quality ratings were recorded from February to August. Air quality ratings in the Poor category were observed in June, July and August. O_3 was the major pollutant which contributed to the IQUA for all months, although much more frequently in the spring and summer seasons. NO_2 and the COH contributed significantly to IQUA ratings in the winter and fall.

4.1.1.4 *Fort McMurray*

The air quality index was in the Good category over 90% of the time in January and February and from July to December at Fort McMurray. The greatest frequency of Fair IQUA readings was evident in April and May where 42% and 48% of readings were in the Fair category, respectively. Poor air quality ratings were recorded in the spring at Fort McMurray. The majority of IQUA readings were based on O_3 throughout the year, with a trend towards higher contributions in the spring and summer seasons. NO_2 and the COH also were important contributors to the air quality index.

4.2 WIND

4.2.1 *Results*

Wind speed and direction are routinely monitored at the 10-m level at the Edmonton residential and industrial, Calgary residential and industrial, Fort Saskatchewan, Fort McMurray and Fort MacKay monitoring locations. Wind direction frequency distributions for Edmonton and Calgary monitoring stations; and Fort Saskatchewan, Fort McMurray and Fort MacKay monitoring stations are presented in Figures 4-4 and 4-5, respectively.

4.2.1.1 *Edmonton*

Wind direction frequencies are distributed fairly evenly around the compass at the Edmonton residential monitoring station although, winds with a westerly component are more frequent than those with an easterly component. The highest frequency of winds were from the west-northwest direction (almost 10%). About 40% of the winds were from the west to north directions.

The wind direction pattern at the industrial monitoring location exhibits a less uniform distribution than that at the residential location. Winds from the south-southeast to the south-southwest (30%) and west-northwest to north (30%) were most frequent while winds with a northeast component and from the west-southwest directions were least frequent.

4.2.1.2 *Calgary*

Almost 54% of winds were from the west-southwest to northwest directions at the Calgary residential monitoring station in 1990. The lowest frequency of winds were from the south-southwest and south directions. Significantly high frequencies of winds from the southeast direction are also noted.

At the industrial location winds with northwest (45%) and southeast (25%) components were most frequent. Wind directions from the northeast were least frequent. Winds from the remaining directions were relatively evenly distributed.

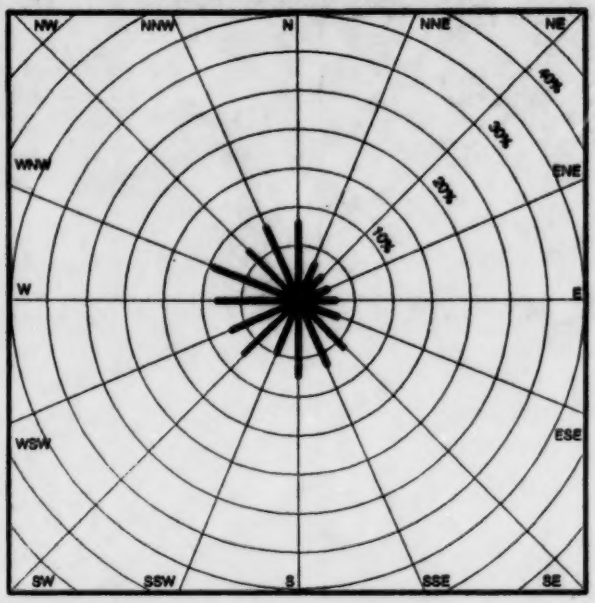
4.2.1.3 *Fort Saskatchewan*

Winds were fairly evenly distributed over all directions at the Fort Saskatchewan monitoring station. The highest frequency of winds were from the south to southwest directions (26%) while the lowest frequency of winds were from northeast direction (8%).

4.2.1.4 *Fort McMurray*

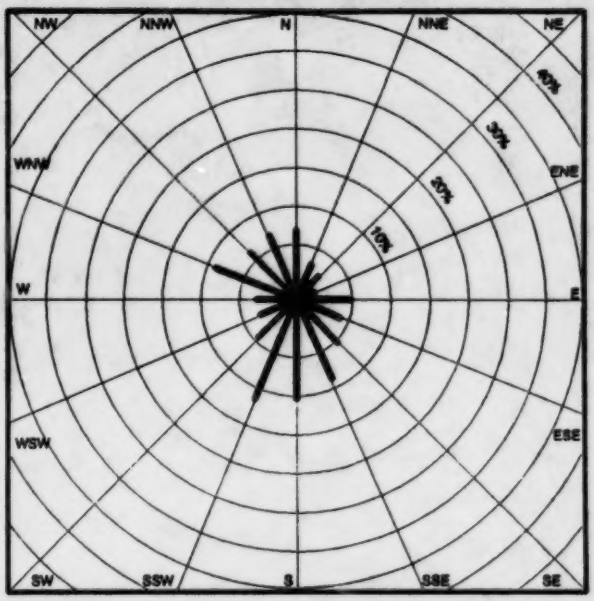
The predominant wind directions at the Fort McMurray monitoring station were from the south-southeast to south and north to north-northeast. Approximately 40% of the winds were from these directions. This wind direction pattern is likely influenced by the

Edmonton Residential



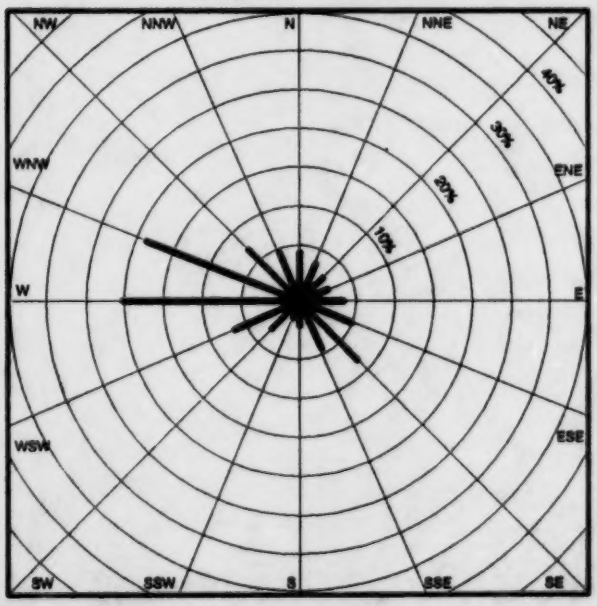
calm = 2.92%

Edmonton Industrial



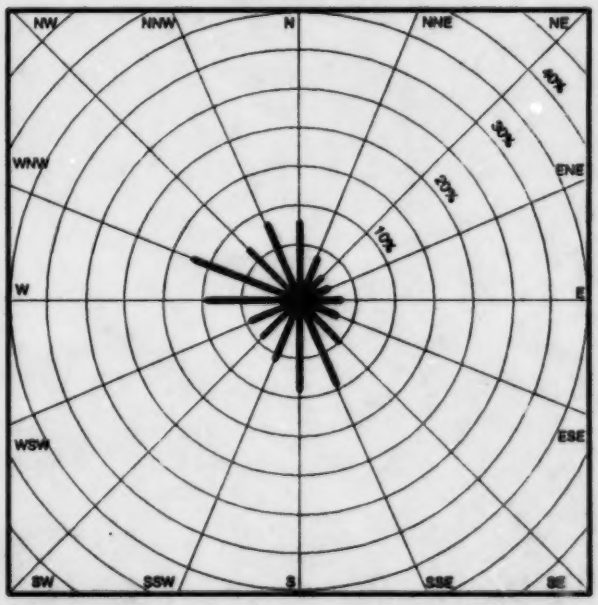
calm = 0.87%

Calgary Residential



calm = 0.08%

Calgary Industrial



calm = 0.32%

note: wind not monitored at Edmonton and Calgary downtown stations

Figure 4-4 Frequency distribution of wind direction at Edmonton and Calgary monitoring locations in 1990.

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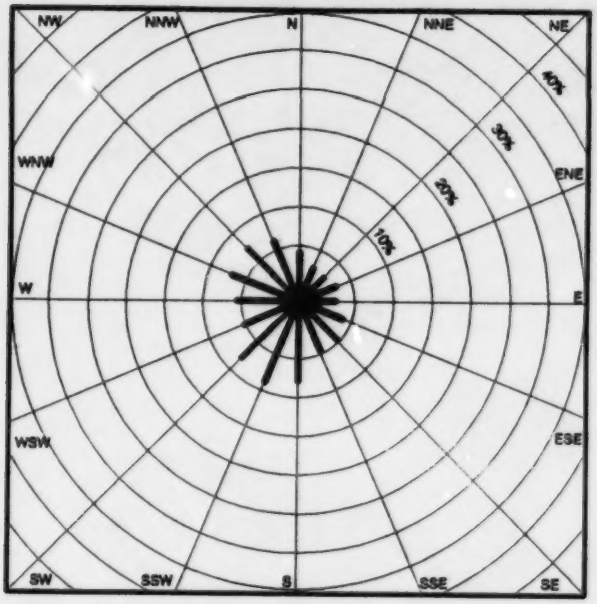
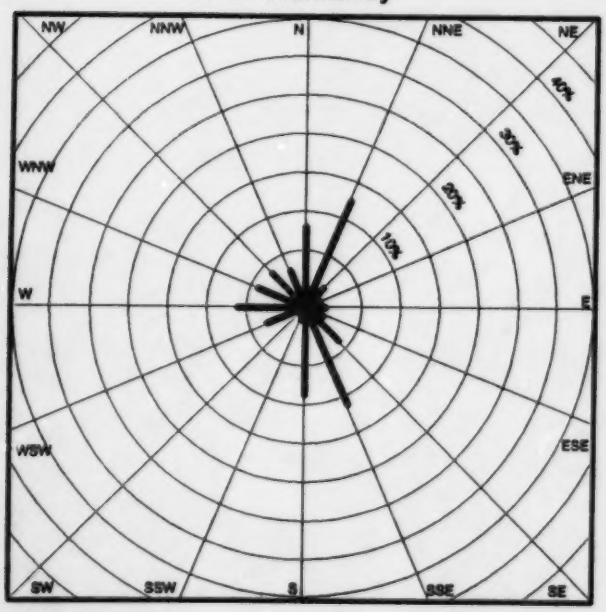
Fort Saskatchewan



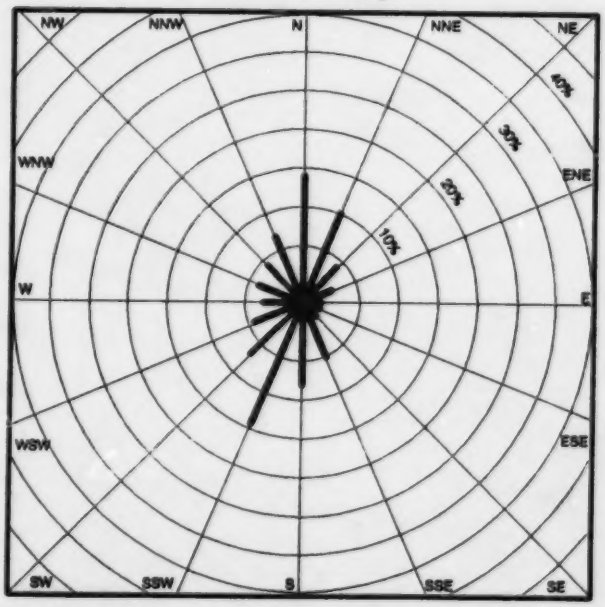
calm = 8.24%

Fort McMurray



calm = 22.5%

Fort MacKay



calm = 3.24%

Figure 4-5 Frequency distribution of wind direction at Fort Saskatchewan, Fort McMurray and Fort MacKay monitoring locations in 1990.

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location of the Athabasca River valley which runs northeast to north through the city of Fort McMurray. A very low frequency of winds were from the southwest and east directions.

4.2.1.5 Fort MacKay

The highest frequency of wind directions at Fort MacKay were from the south-southeast to the southwest and the north-northwest to the north-northeast directions. About 66% of winds were from these directions. Winds from the east and west directions were less frequent. This wind direction frequency distribution reflects the location of the Fort MacKay monitoring unit with respect to the Athabasca River valley which is situated in a north-south direction.

4.3 AMMONIA (NH_3)

4.3.1 Characteristics

NH_3 is a colourless gas with the well-known pungent odour found in household cleaners. NH_3 occupies a unique position as it is generally considered to be a desirable chemical, particularly in fertilizers, and not as a potential environmental pollutant. While NH_3 is produced both by natural and man-made sources, it is emitted mainly from natural sources through the decay of plant and animal material, animal waste and a small portion is released during respiration. Of all the natural sources, by far the largest is from the degradation of dead plants and animals. The other major natural source of ammonia is animal by-products.

In Alberta, the fertilizer industry is the main industrial source of NH_3 (52%). The industry produces synthetic NH_3 for either direct application to the soils as a fertilizer or as a raw material in the production of other high nitrogen fertilizer products. The other major source of NH_3 is commercial feedlots where the large amounts of animal waste can be a significant source (40%).

4.3.2 *Method of Monitoring*

NH_3 is monitored continuously by the same principle as NO_2. In this method the air sample is split into two pathways. In the first, all NH_3 (as well as NO) in the sample is converted to NO by a catalyst and high temperatures (adding to the NO already in the sample). The concentration is measured by mixing the sample with O_3 and utilizing a chemiluminescence reaction to detect the amount of visible light produced. In the second pathway, at a temperature too low to convert NH_3, oxides of nitrogen are reduced to NO by a catalytic converter (adding to the NO already in the sample) and the chemiluminescence process repeated. The difference between the two readings is then calculated to be the concentration of NH_3.

4.3.3 *Regulations and Guidelines*

Alberta Environment currently regulates NH_3 emissions by licencing each industrial source and limiting their emissions according to their Licence to Operate. In addition, each plant is required to monitor their emissions and report when ambient concentrations of NH_3 exceed 2.0 ppm as a 1-hour average.

4.3.4 *Results*

4.3.4.1 *Fort Saskatchewan*

NH_3 is monitored by Alberta Environment at the Fort Saskatchewan monitoring station because of its proximity to the fertilizer industry. Figure 4-6 shows a frequency distribution of NH_3 concentrations by month and annual average concentrations. Ambient NH_3 concentrations were below the detectable limit over 90% of the time for every month in 1990. A peak NH_3 concentration of 1.3 ppm was recorded in August. This value is 65% of the 1-hour average regulation for NH_3. Annual average NH_3 concentrations are generally too low to resolve a significant trend.

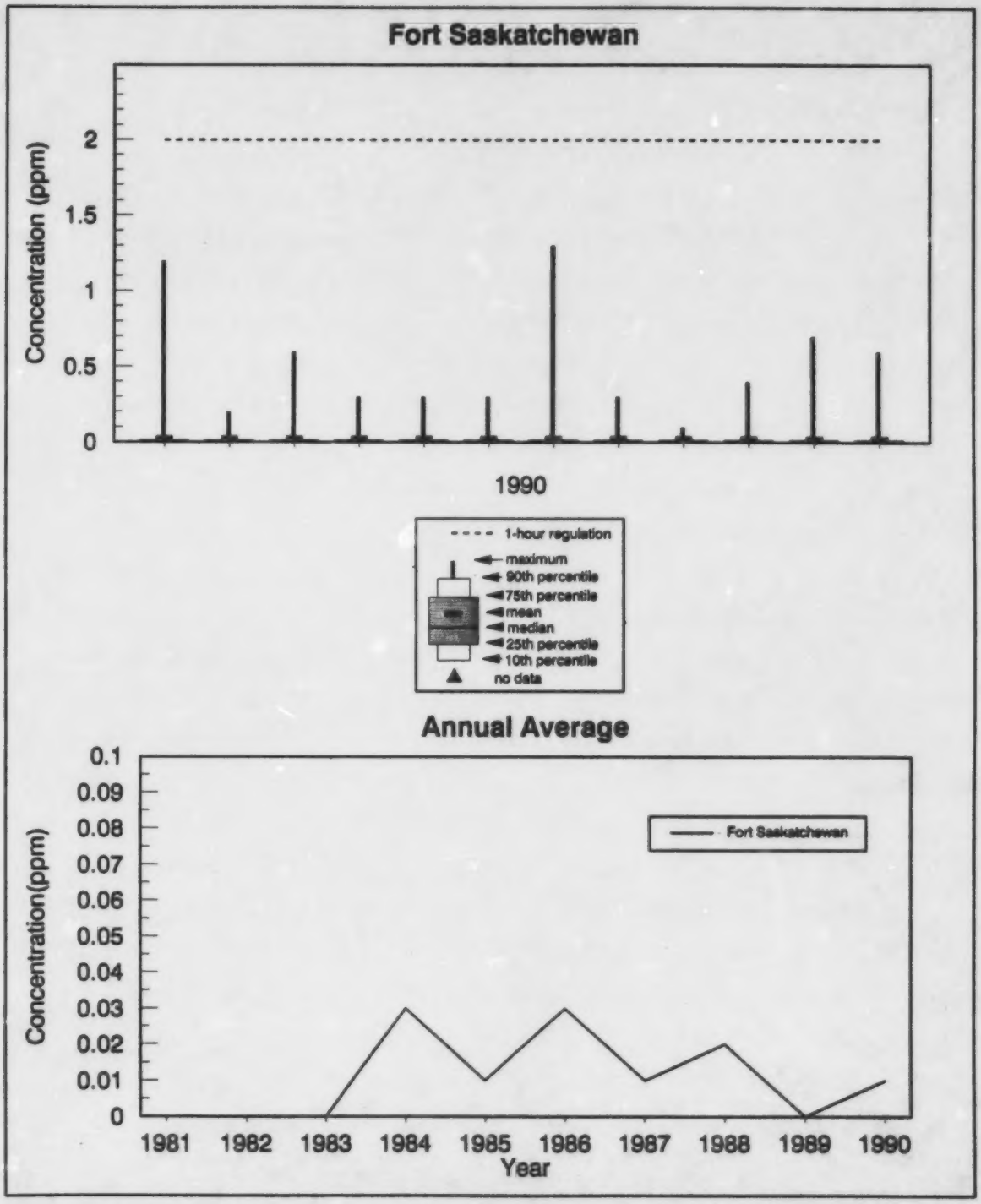

Figure 4-6 Frequency distribution of ammonia concentrations at Fort Saskatchewan.

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4.4 CARBON MONOXIDE (CO)

4.4.1 Characteristics

CO, a common pollutant in urban areas, is a colourless, odourless gas. The majority of the CO found in urban air comes from incomplete combustion of carbon-based fuels. The primary source of urban CO is motor vehicles, with much smaller contributions from fireplaces, industrial sources, aircraft and natural gas combustion.

The relationship between vehicular traffic and CO is apparent at urban locations during morning and evening rush hours. CO concentrations also fluctuate seasonally. The highest concentrations occur during the late autumn, winter and early spring because: (1) in cold weather, motor vehicles run less efficiently; (2) vehicle warmup and idling times are increased; and (3) meteorological conditions, such as stable atmospheric conditions and low wind speeds result in decreased dispersion.

4.4.2 Method of Monitoring

CO is monitored continuously by either non-dispersive infrared photometry or gas filter correlation. The non-dispersive infrared photometry process is based upon the absorption of infrared light by CO. Gas filter correlation is operated on the same principle as non-dispersive infrared photometry and is also based on the absorption of light by CO.

4.4.3 Regulations and Guidelines

The regulations governing the maximum permissible concentration of CO are based on the prevention of human health effects. In regulating CO, Alberta has adopted Environment Canada's most rigorous ambient air quality regulations. Maximum permissible CO concentrations are:

- 13.0 ppm as a 1-hour average concentration; and
- 5.0 ppm as an 8-hour average concentration.

4.4.4 Results

CO was monitored, on a continuous basis, at all three Edmonton and Calgary air quality stations, and at the Fort Saskatchewan and Fort McMurray monitoring stations. Frequency distributions of monthly CO concentrations and annual average CO concentrations are illustrated in Figures 4-7 to 4-9. Annual average CO concentrations ranged from 0.45 ppm at Fort Saskatchewan to 1.42 ppm at the Edmonton downtown monitoring station. Relatively high annual average CO concentrations were also evident at the Calgary downtown (1.26 ppm), Edmonton residential (1.07 ppm) and Calgary industrial (1.06 ppm) monitoring locations.

CO concentrations are generally higher in the autumn and winter months than the spring and summer months. In the winter, temperature inversions are more likely to persist throughout the day due to a lack of solar heating. Persistent inversions coupled with longer vehicular warmup and idling times lead to increased CO concentrations during the late autumn and winter months. In Calgary, high pollution episodes are most likely the result of pollutants trapped near the ground prior to chinook.

A well-defined diurnal variation of CO concentrations was evident at most air quality monitoring stations. CO peaks are evident during the morning and afternoon traffic rush hours. Minimum CO values are generally recorded overnight when vehicular traffic is at a minimum.

4.4.4.1 Edmonton

A total of seven hours exceeded the 1-hour average regulation for CO at the Edmonton residential monitoring location in 1990. The maximum 1-hour average CO concentration observed at the Edmonton downtown, residential and industrial monitoring stations were 12.6, 16.8 and 4.0 ppm, respectively. These peak values were recorded in October at all monitoring stations. High CO concentrations at the downtown and residential monitoring stations are caused directly by vehicular traffic in the vicinity of the stations. Over 40% of exceedances at the residential location were observed when the winds had a westerly component. A major traffic artery is located in this direction (i.e. 127 St.).

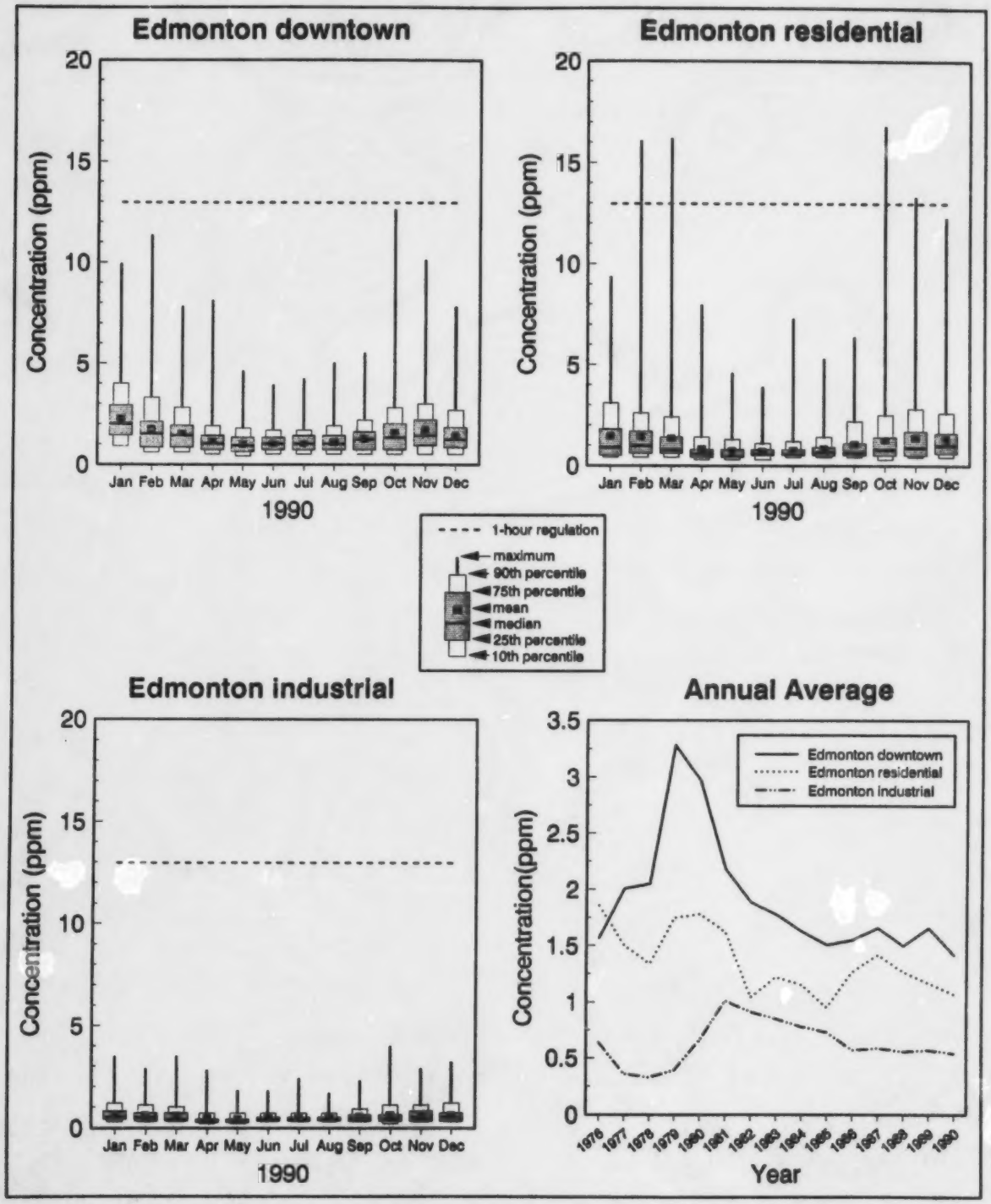

Figure 4-7 Frequency distribution of carbon monoxide concentrations at Edmonton.

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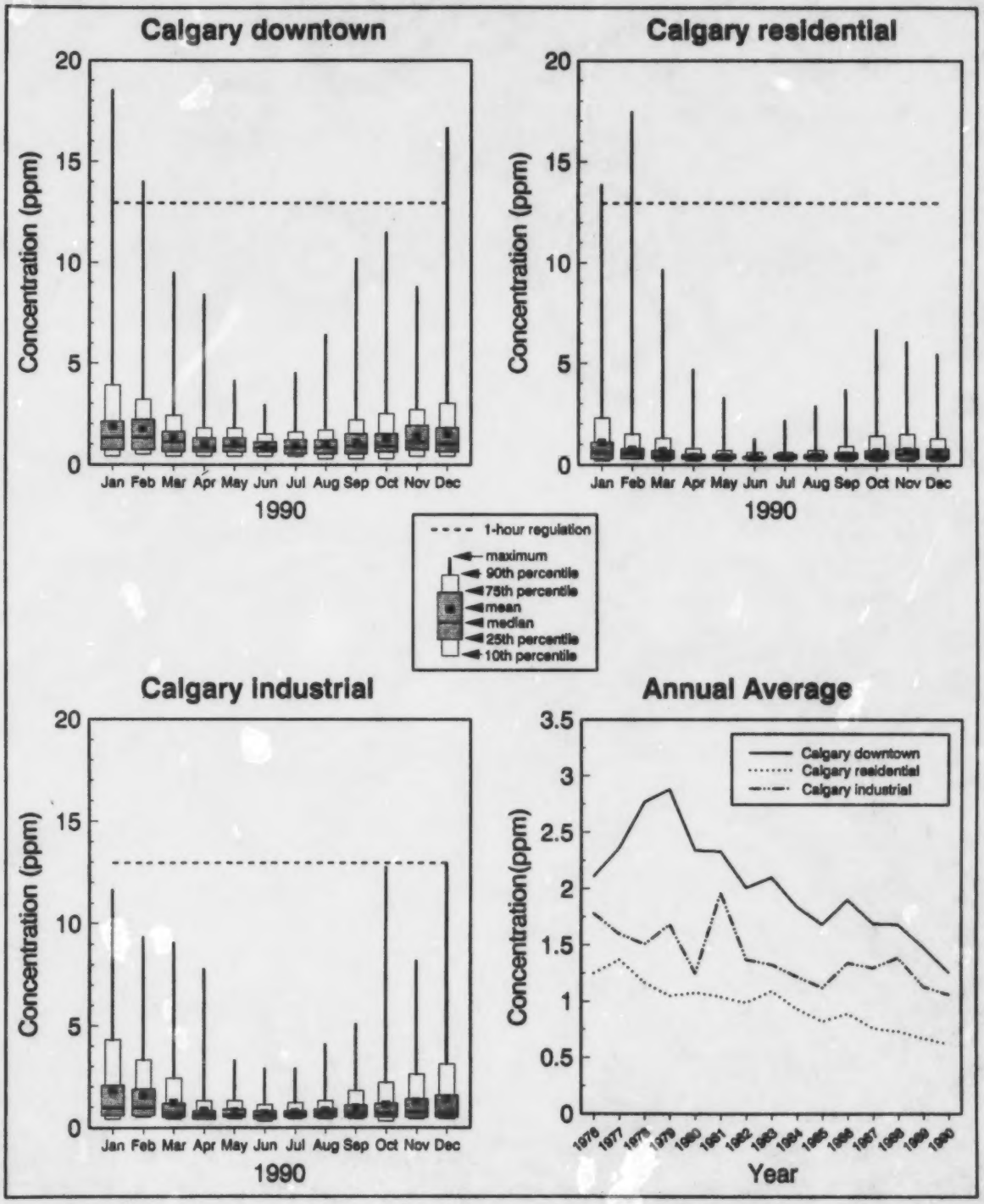

Figure 4-8 Frequency distribution of carbon monoxide concentrations at Calgary.

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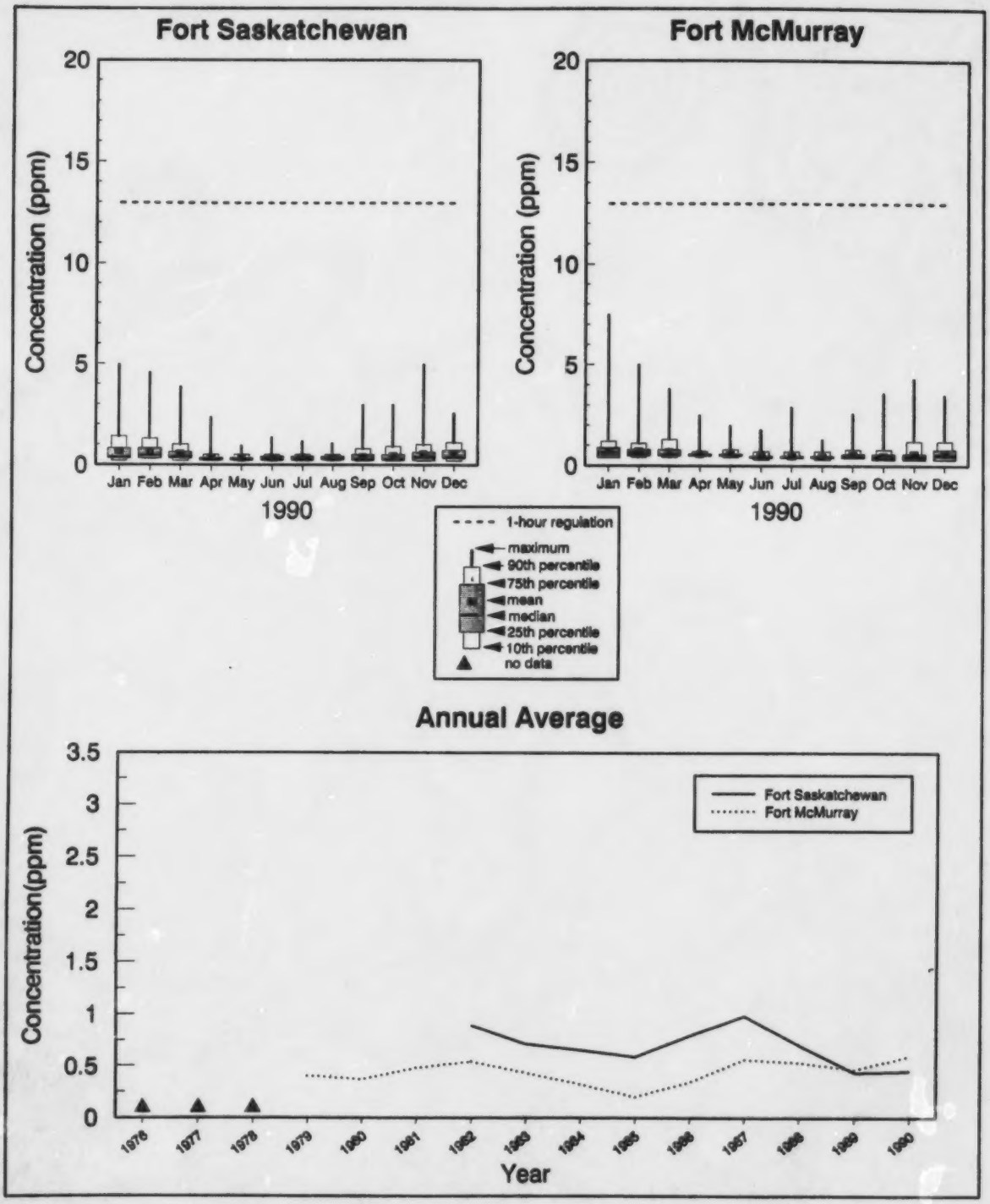

Figure 4-9 Frequency distribution of carbon monoxide concentrations at Fort Saskatchewan and Fort McMurray.

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The 8-hour average regulation for CO, was exceeded seven times at each of the Edmonton downtown and residential monitoring units. The majority of these exceedances were recorded in the fall and winter. Maximum 8-hour average CO concentrations were 7.8, 9.2 and 2.2 ppm, respectively, at the downtown, residential and industial monitoring stations. Winds at the residential monitoring location during times when the 8-hour average regulation was exceeded were predominantly from the south-southwest to north-northwest directions. A relatively high frequency of winds were also from the northeast and east-southeast directions. Major traffic arteries are located in these directions.

A downward trend in annual average CO concentrations is indicated at the Edmonton downtown and residential monitoring stations. This downward trend may be attributed to lower emissions from vehicles due to more efficient engines and less older vehicles on the road.

4.4.4.2 Calgary

Exceedances of the 1-hour regulation for CO were noted at all Calgary monitoring stations. All exceedances of the regulation were recorded in the winter at the Calgary monitoring stations. A total of 10, 2 and 1 exceedances were observed at the downtown, residential and industrial monitoring stations respectively. A peak hourly-average value of 18.5 ppm was recorded in January at the Calgary downtown location.

The 8-hour regulation was exceeded 8, 3 and 8 times at the downtown, residential and industrial monitoring locations, respectively. All exceedances occurred in the winter or early spring months. The overall maximum CO concentrations at the downtown, residential and industrial monitoring locations were 10.7, 6.6 and 7.4 ppm, respectively.

A significant downward trend in the annual average concentration of CO is evident at all Calgary monitoring stations. This trend may be due to decreased vehicular emissions of CO.

4.4.4.3 Fort Saskatchewan

The 1- and 8-hour regulations for CO were not exceeded at the Fort Saskatchewan monitoring unit in 1990. The peak 1- and 8- hour average CO concentrations were 5.0 ppm and 2.7 ppm, respectively. A significant trend in annual average CO concentrations is not evident at the Fort Saskatchewan monitoring location.

4.4.4.4 Fort McMurray

Exceedances of the 1- and 8-hour regulations were not observed at the Fort McMurray monitoring unit in 1990. Maximum 1- and 8-hour average values for CO of 7.5 and 4.2 ppm, respectively, were observed in January at the Fort McMurray monitoring station. Annual average CO data collected at Fort McMurray do not show a significant historical trend.

4.5 COEFFICIENT OF HAZE (COH)

4.5.1 Characteristics

The interaction of particles with sunlight and atmospheric moisture can result in diminished visibility (haze). The coefficient of haze is an index which corresponds to the reduction of transmitted light, or visibility reduction, due to particulate matter in the form of dust and smoke.

4.5.2 Method of Monitoring

Air samples are collected continuously by drawing a known volume of air through a filter paper for a period of one hour. The soiling properties of the sample are measured by the reduction of light transmission through the filter tape. This reduction is reported as the coefficient of haze per 1000 linear feet of air sample. This method does not measure the absolute concentration or deposited mass of particulates but rather is an index of fine suspended particulate matter in the air.

4.5.3 Regulations and Guidelines

Guidelines regarding the COH are based on visibility reduction. Alberta Environment has established that:

- 90% of the COH readings per month shall be less than 1.0 COH unit.

4.5.4 Results

The COH was monitored at all Edmonton, Calgary, Fort Saskatchewan and Fort McMurray monitoring units. Annual average COH indices ranged from 0.07 COH units at Calgary residential and Fort Saskatchewan monitoring units to 0.24 COH units at the Calgary industrial monitoring location. Relatively high annual average COH values were also indicated at Edmonton downtown (0.20 COH units), residential (0.23 COH units) and industrial (0.21 COH units) monitoring sites as well as the Calgary downtown (0.22 COH units) monitoring location.

All stations show a seasonal trend with higher COH levels during the winter and autumn months. Meteorological conditions in the winter and autumn months are often favourable for the accumulation of pollutants within the lower atmosphere. The largest source of urban particulates is likely automobile emissions. Other sources include emissions from industrial sources, and dust from the streets in the winter and early spring.

Substantial maximums in COH values were recorded during the morning and afternoon rush hours at the Calgary and Edmonton monitoring stations. This diurnal tendency is not as prevalent at the Fort Saskatchewan and Fort McMurray monitoring stations. Frequencies of monthly COH values and are presented in Figures 4-10 to 4-12. The trends of annual average COH values are also illustrated in these figures.

4.5.4.1 Edmonton

All three Edmonton stations recorded at least 90% of the COH readings less than the guideline level of 1.0 COH on a monthly basis. The highest frequency of values which exceeded 1.0 COH unit was 3.1%, 4.7% and 5.2% at the downtown, residential and industrial monitoring locations, respectively. These frequencies were observed in September at the industrial monitoring location and October at the downtown and residential monitoring locations. A maximum 1-hour average COH value of 6.1 COH units was observed in May at the industrial monitoring location. A significant trend in annual COH values is not evident at Edmonton monitoring stations.

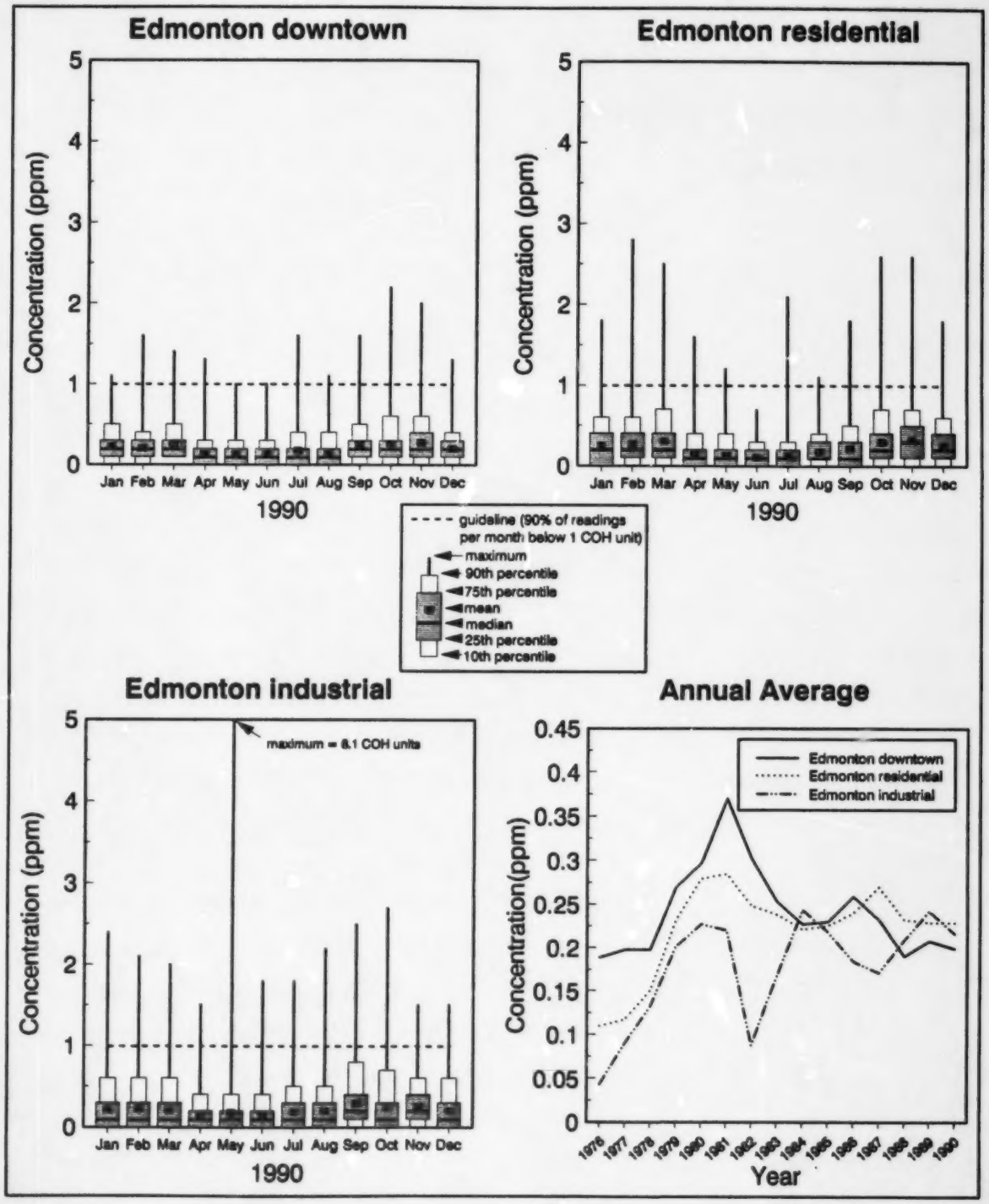

Figure 4-10 Frequency distribution of the coefficient of haze at Edmonton.

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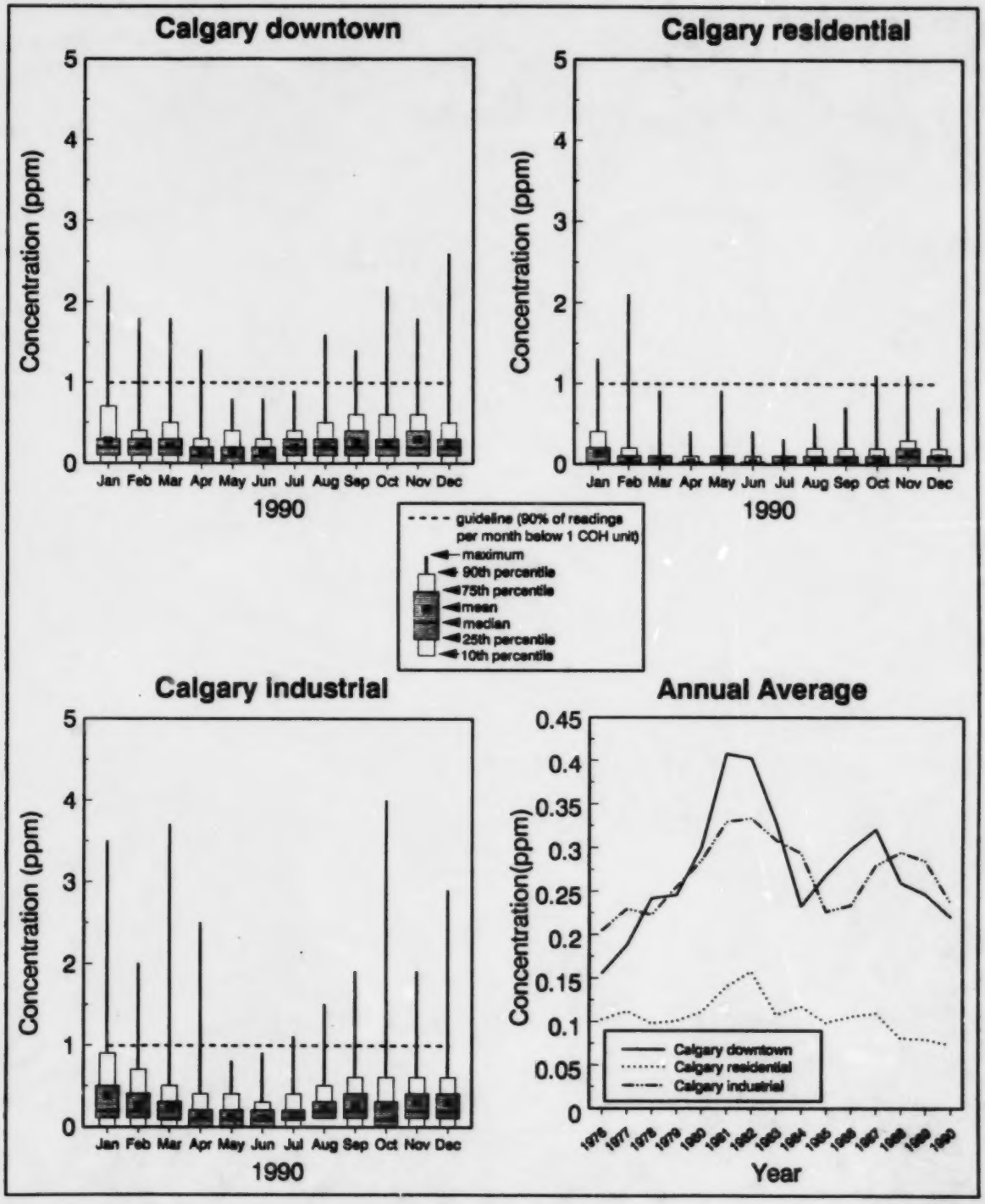

Figure 4-11 Frequency distribution of the coefficient of haze at Calgary.

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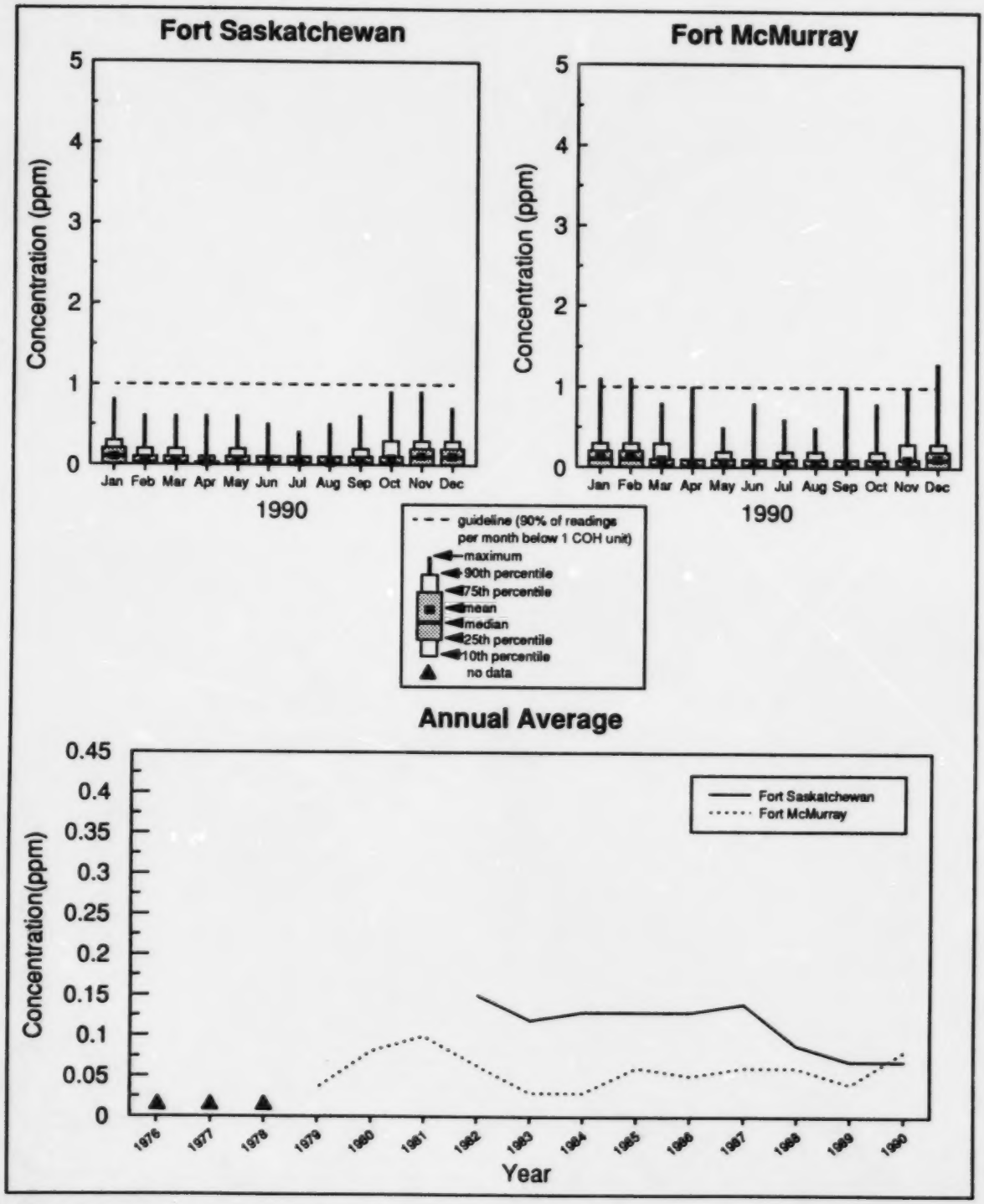

Figure 4-12 Frequency distribution of the coefficient of haze at Fort Saskatchewan and Fort McMurray.

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4.5.4.2 Calgary

Exceedances of the guideline for the COH were not recorded at any Calgary monitoring stations in 1990. A maximum frequency of 7.6% of COH values greater than 1.0 COH unit was recorded in January at the industrial monitoring site. Maximum frequencies of 4.0 and 1.5% of values greater than 1.0 COH unit were recorded in January at the Calgary downtown and residential monitoring locations, respectively. A peak COH value of 4.0 COH units was observed in October at the Calgary industrial monitoring location. Significant trends in annual average COH values were not observed at any Calgary monitoring locations.

4.5.4.3 Fort Saskatchewan

Exceedances of the guideline for the COH were not observed at the Fort Saskatchewan monitoring station. No values over 1.0 COH unit were recorded at Fort Saskatchewan. A maximum index of 0.9 COH units was recorded in October and November. A trend in annual average COH is not detectable at the Fort Saskatchewan monitoring station.

4.5.4.4 Fort McMurray

The maximum COH value recorded in Fort McMurray was 1.3 COH units. The guideline for COH was not exceeded in Fort McMurray during 1990. The highest frequency of values that exceeded 1.0 COH unit was 0.3% which occurred in January. Annual average COH values do not show a trend at Fort McMurray.

4.6 HYDROGEN SULPHIDE (H_2S)

4.6.1 Characteristics

H_2S is a colorless gas with a characteristic rotten egg odour. The gas is heavier than air and therefore concentrations tend to remain near the earth's surface. H_2S is produced both naturally and through industrial processes. H_2S is found naturally in coal, natural gas, oil, sulphur hot springs, sloughs, swamps and lakes. It is also produced under

anaerobic conditions in the decomposition of sulphur-containing bacteria. Decomposition of sulphur-containing bacteria is responsible for the rotten egg odour commonly associated with marshes, sewers, and sewage lagoons.

While most of the H_2S in the atmosphere is from natural sources, industrial sources have a significant impact on the environment. These industrial sources are primarily petroleum refining, natural gas plants, petrochemical complexes, coke oven plants, and pulp and paper mills employing the kraft pulping process.

4.6.2 Method of Monitoring

H_2S is measured continuously by pulsed fluorescence. In this method, air is drawn through a sample chamber where it is irradiated with pulses of ultra-violet light. Any H_2S in the sample is excited to a higher energy level and upon returning to is its original state, light or fluorescence is released. The amount of fluorescence measured is proportional to the H_2S concentration.

4.6.3 Regulations and Guidelines

The regulations governing the maximum permissible concentration of H_2S is based on the odour threshold although, many individuals can smell H_2S at levels below the ambient regulations. In regulating H_2S, Alberta has adopted Environment Canada's most rigorous ambient regulation with a maximum permissible concentration of:

- 0.010 ppm as a 1-hour average concentration; and
- 0.003 ppm as a 24-hour average concentration.

4.6.4 Results

H_2S is monitored at the Calgary industrial, Fort Saskatchewan, Fort McMurray and Fort MacKay monitoring units. Percentile diagrams for monthly concentrations and annual average concentrations from these stations are presented in Figures 4-13 and 4-14. Annual average H_2S concentrations were 0.001 ppm at the Calgary industrial and Fort Saskatchewan monitoring locations. All other stations recorded 0.000 ppm as an annual average. Since H_2S concentrations were low at most locations, seasonal, diurnal and annual

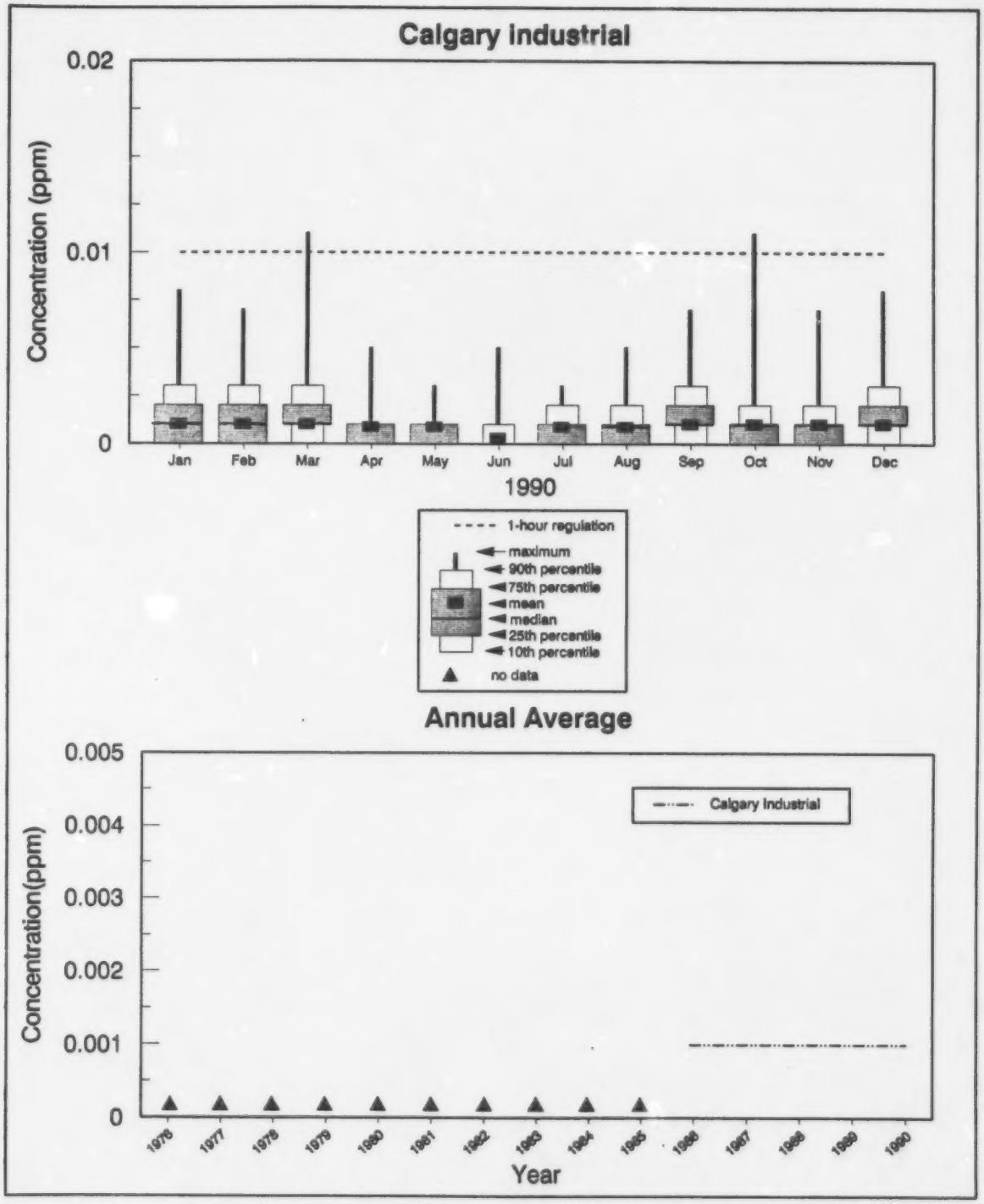

Figure 4-13 Frequency distribution of hydrogen sulphide concentrations at Calgary.

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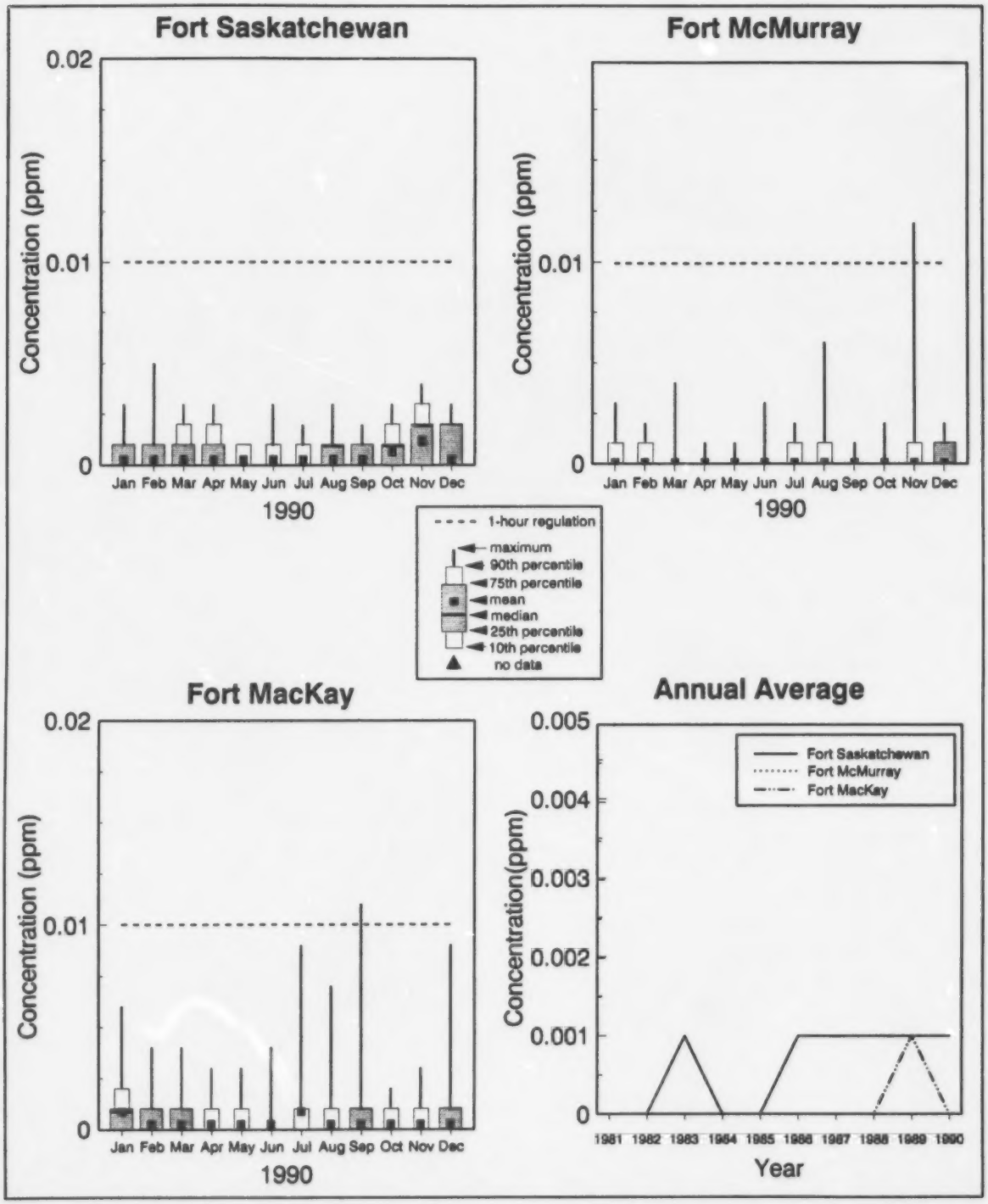

Figure 4-14 Frequency distribution of hydrogen sulphide concentrations at Fort Saskatchewan, Fort McMurray and Fort MacKay.

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trends were not distinguishable, however, episodic exceedances of the regulations are observed.

4.6.4.1 Calgary

A total of four exceedances of the 1-hour regulation for H_2S were detected at the Calgary industrial monitoring station. These exceedances were recorded in March and October. A maximum H_2S value of 0.011 ppm was recorded in March at the industrial monitoring location. A total of two days exceeded the 24-hour regulation for H_2S at the industrial monitoring location in 1990. These values were recorded in March and December.

Winds during times of exceedances of the 1-hour regulation were from the south-southeast, southeast and north-northwest directions. Winds were from the southeast to southwest directions when exceedances of the 24-hour regulation were observed. Sources of exceedances were likely fugitive emissions from industrial sources in the vicinity. Strong temperature inversions were present during these episodic exceedances.

4.6.4.2 Fort Saskatchewan

Exceedances of the regulations for H_2S were not observed at Fort Saskatchewan monitoring location. The maximum 1-hour average concentration were 0.005 ppm which occurred in February. Sources of H_2S in the region are likely fugitive emissions from local petroleum refineries and sewage lagoons located in northeast Edmonton.

4.6.4.3 Fort McMurray and Fort MacKay

The 1-hour regulation for H_2S was exceeded one time at both the Fort McMurray and Fort MacKay monitoring stations. These exceedances were recorded in November and September at the Fort McMurray and Fort MacKay monitoring stations, respectively. Maximum 1-hour concentrations of 0.012 and 0.011 ppm were recorded at these two stations, respectively. The 24-hour regulation for H_2S was not exceeded at the Fort McMurray or Fort MacKay monitoring stations.

The wind was calm at the Fort McMurray monitoring station when the exceedance of the 1-hour regulation was observed. South-southwest winds were prevalent when the exceedance of the regulation was recorded at Fort MacKay. These two stations are located in the vicinity of large oil sands facilities where fugitive emissions of H_2S are common from the processing of bitumen into crude oil.

4.7 OXIDES OF NITROGEN (NO_x)

4.7.1 Characteristics

Oxides of nitrogen are appear in the ambient atmosphere as nitrogen dioxide (NO_2), nitrogen oxide (NO) and nitrous oxide (N_2O). Alberta Environment monitors for NO_2, NO, and NO_x on a continuous basis.

During high temperature combustion, as in the burning of natural gas, coal, oil and gasoline, atmospheric nitrogen may combine with molecular oxygen to form NO. NO is colourless, odourless and has no known toxic effects. Most of the NO is rapidly oxidized to form NO_2. NO_2 is a reddish-brown gas with a characteristic pungent odour. NO_2 is partially responsible for the brownish discolouration of the lower atmosphere near urban areas.

Nitrous oxide is a naturally occurring, sweet smelling, non-toxic gas in the ambient atmosphere. For the purposes of air quality monitoring, total oxides of nitrogen (NO_x) is considered to be the sum of the concentration of NO_2 and NO. Nitrous oxide is not included as a contributor to total oxides of nitrogen in ambient air quality monitoring because ambient concentrations are generally very low.

In Alberta, about 38% of NO_x emissions are contributed by the oil and gas industry, 29% by transportation and 16% by power plants. The remaining 17% originate from natural gas and heating fuel combustion, agricultural fuel consumption and other industries (Alberta Environment 1990).

4.7.2 *Method of Monitoring*

Oxides of nitrogen are measured continuously by the principle of chemiluminescence. In this method, the air sample is split into two pathways. In the first pathway, the NO concentration is measured by mixing ozone with the sample and detecting the amount of visible light produced when NO_2 reacts with O_3. In the second pathway, all the NO_2 in the sample is reduced to NO by a catalytic converter. The difference between the two readings is the concentration of NO_2.

4.7.3 *Regulations and Guidelines*

The regulations governing the maximum permissible concentration of NO_2 are based on the prevention of human health effects. In regulating NO_2, Alberta has adopted the most rigorous ambient regulations set by Environment Canada with a maximum average concentration of:

- 0.21 ppm as a 1-hour average concentration;
- 0.11 ppm as a 24-hour average concentration; and
- 0.03 ppm as an annual arithmetic average.

There are no regulations for ambient concentrations of NO and NO_x.

4.7.4 *Results*

NO_2, NO and NO_x are monitored routinely at all Edmonton, Calgary, Fort Saskatchewan and Fort McMurray monitoring sites. Because NO and NO_x are monitored for the purpose of determining concentrations of NO_2, only NO_2 will be discussed in this section. Figures 4-15 to 4-17 show monthly frequency distributions for NO_2 at each monitoring location. Annual average concentrations are also presented in these figures.

Annual average NO_2 concentrations ranged from 0.011 ppm at Fort McMurray to 0.034 ppm at the Calgary downtown monitoring unit. The Edmonton downtown (0.027 ppm), residential (0.025 ppm) and Calgary industrial (0.027 ppm) monitoring units also recorded relatively high annual average NO_2 concentrations. Higher NO_2 concentrations at these locations are mainly due to a higher density of vehicular traffic and also the usage of heating fuels.

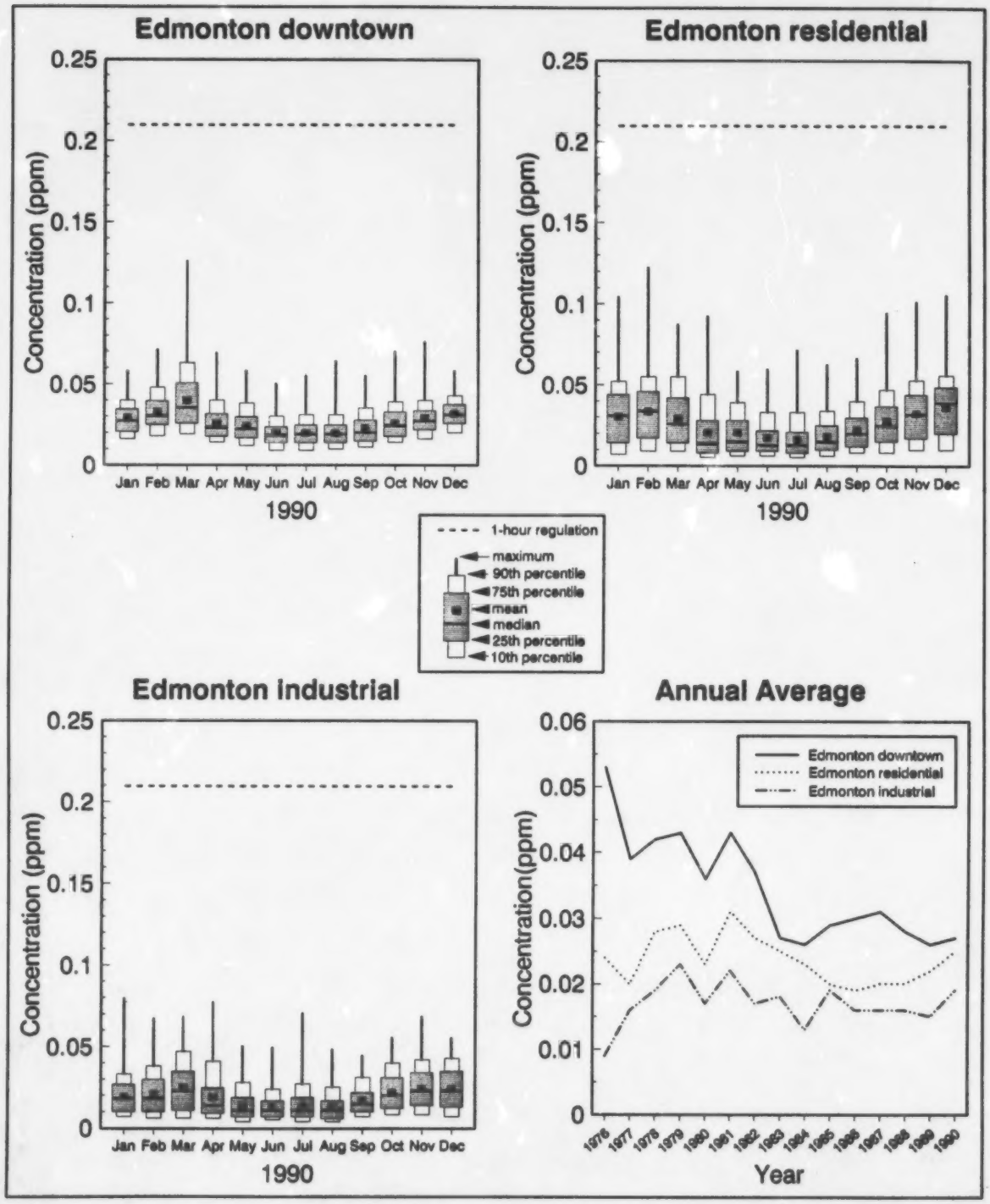

Figure 4-15 Frequency distribution of nitrogen dioxide concentrations at Edmonton.

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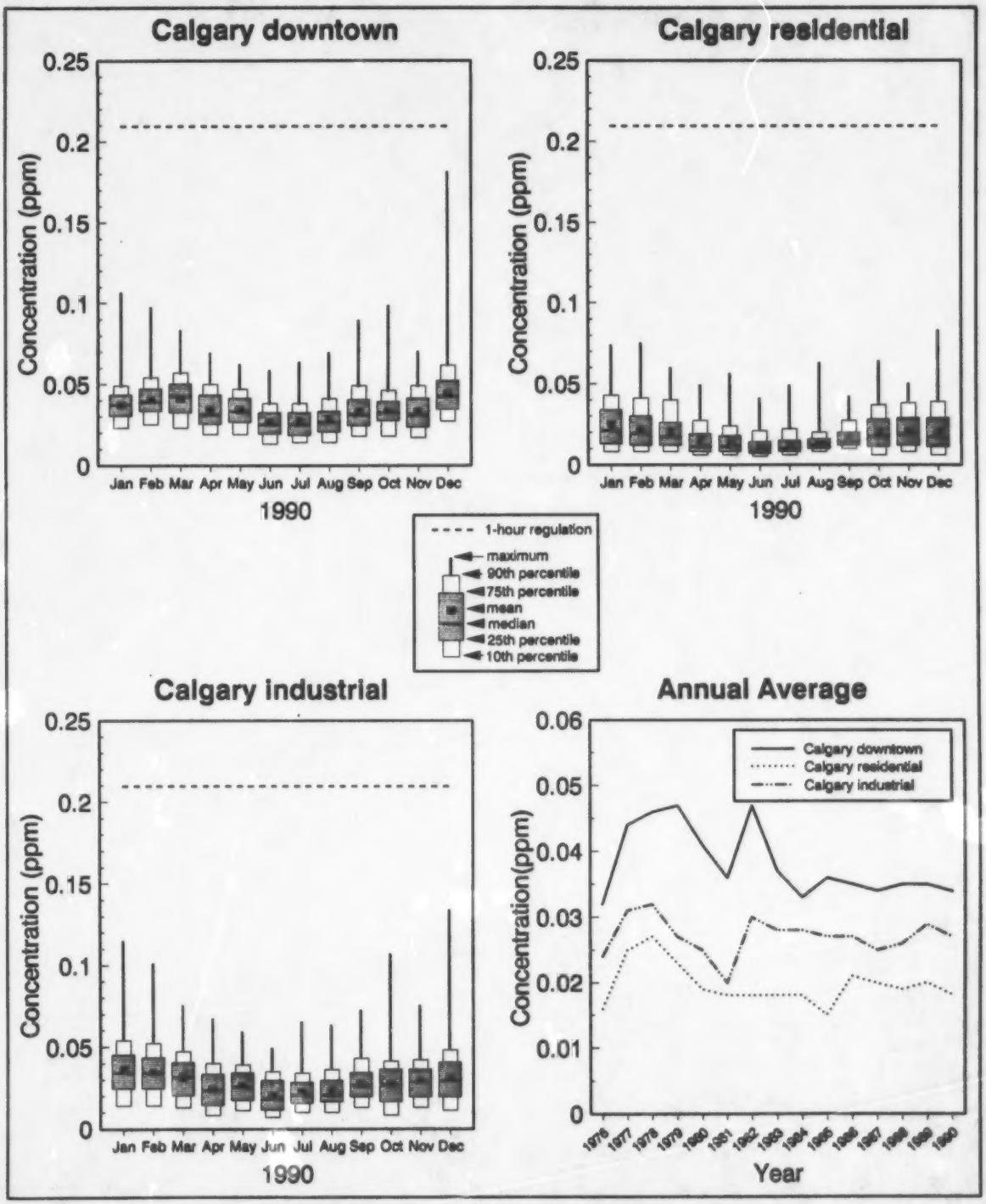

Figure 4-16 Frequency distribution of nitrogen dioxide concentrations at Calgary.

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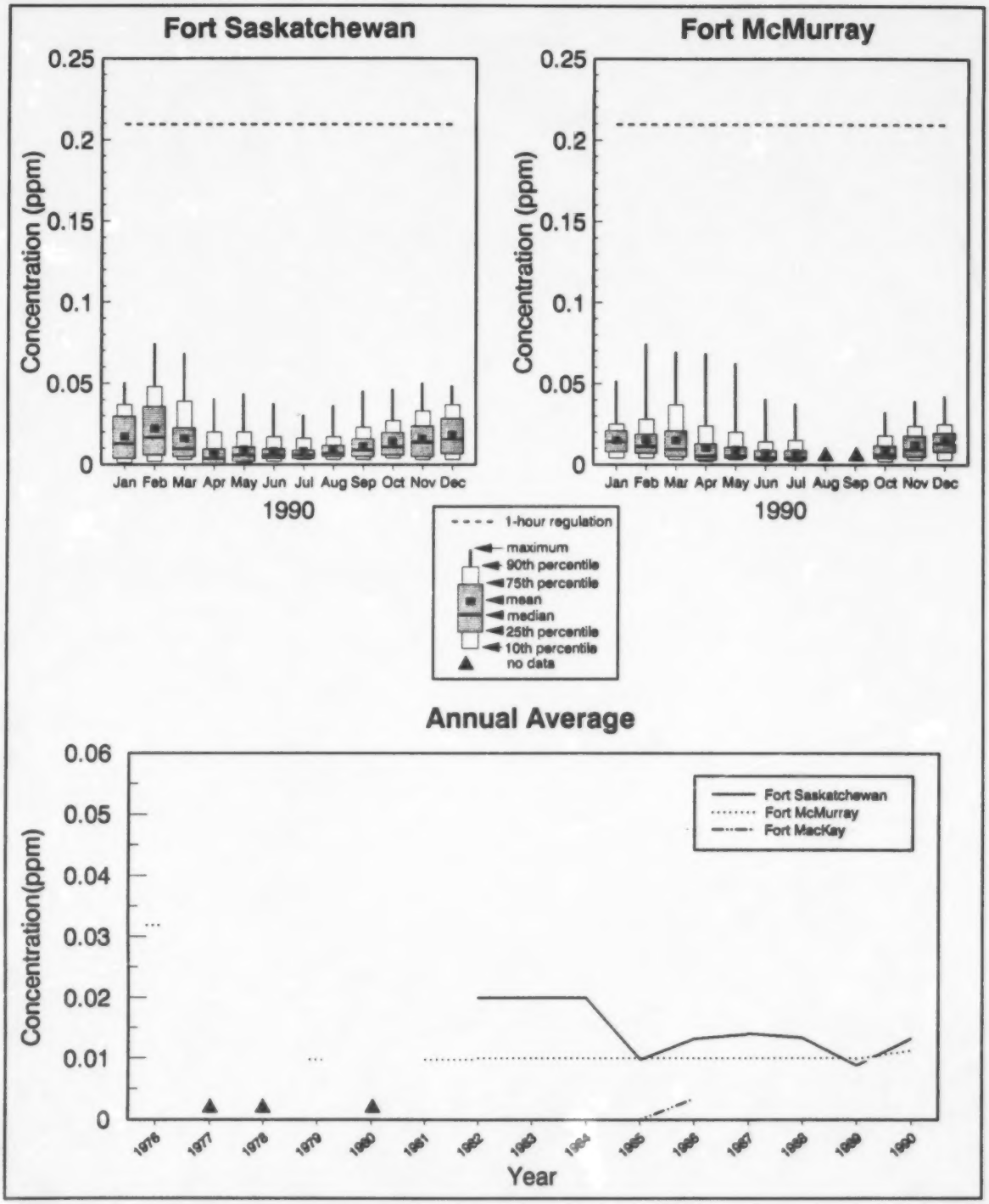

Figure 4-17 Frequency distribution of nitrogen dioxide concentrations at Fort Saskatchewan and Fort McMurray.

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NO_2 concentrations were substantially greater during the winter season at all locations than during the other seasons of the year. In the winter season, persistent temperature inversions will retard the dispersion of pollutants and therefore, lead to higher pollutant concentrations. Heating fuel consumption and automobile emissions also tend to be the highest during the winter season.

A distinct diurnal trend in NO_2 concentrations was evident at the Calgary and Edmonton urban locations. NO_2 values tended to be at a minimum in the early morning hours. An increase in NO_2 concentrations was evident in the morning rush hour and again in the afternoon rush hour. Concentrations begin to drop again at about midnight. This diurnal trend is especially prevalent during the winter months. A diurnal trend is not apparent at more rural locations such as Fort Saskatchewan and Fort McMurray where vehicular emissions are substantially lower. A trend in annual average NO_2 concentrations is not detectable at Calgary, Fort Saskatchewan or Fort McMurray monitoring stations.

4.7.4.1 Edmonton

The 1-hour, 24-hour and annual average ambient regulations for NO_2 were not exceeded at any of the Edmonton monitoring locations. The maximum 1-hour average NO_2 concentrations at the downtown, residential and industrial monitoring locations were 0.13, 0.12 and 0.08 ppm, respectively. The maximum 24-hour average values were 0.085, 0.061 and 0.045 at the downtown, residential and industrial locations, respectively. These values occurred in March, February and January at the three locations, respectively. The 1-hour regulation for NO_2 is 0.21 ppm. Annual average NO_2 concentrations show a significant downward trend at the Edmonton downtown monitoring station.

4.7.4.2 Calgary

The 1- and 24-hour average regulations for NO_2 were not exceeded at any of the Calgary monitoring locations. However, the annual average regulation of 0.030 ppm was exceeded at the Calgary downtown monitoring unit. A value of 0.034 ppm was recorded at this location. A peak 1-hour average concentration of 0.18 ppm was measured at the Calgary downtown monitoring location. This value is 86% of the ambient air quality regulation for NO_2. The highest 24-hour average NO_2 concentration was 0.082 ppm which occurred at the downtown monitoring station.

4.7.4.3 Fort Saskatchewan

The maximum 1-hour average NO_2 concentration recorded at Fort Saskatchewan was 0.07 ppm. This value is one-third of the 1-hour regulation for NO_2 and was recorded in the month of February. Regulations for 1-hour, 24-hour and annual average NO_2 concentrations were not exceeded in Fort Saskatchewan.

4.7.1.4 Fort McMurray

The ambient air quality regulations for NO_2 were not exceeded at the Fort McMurray monitoring unit in 1990. The peak 1-hour value was 0.07 ppm which was observed in February.

4.8 OZONE (O_3)

4.8.1 Characteristics

At normal ambient concentrations, O_3 is a colourless, odourless gas. However, O_3 does have a characteristics sharp odour when at very high concentrations (i.e., electrical discharges associated with arcing electric motors and lightning storms). Unlike many other pollutants, O_3 is not emitted into the atmosphere directly by man's activities, but is produced through the inter-reaction of other atmospheric constituents. In the upper atmosphere, O_3 is a naturally-occurring compound; in the lower atmosphere, O_3 is the primary end-product of photochemical reactions involving oxides of nitrogen and reactive hydrocarbons (vapours from automobile exhaust, paints, inks, solvents and gasoline) with ultra-violet light from the sun. O_3 is formed through the dissociation of NO_2 by sunlight to yield an oxygen atom, which may react with molecular oxygen to form an O_3 molecule.

The highest levels of O_3 generally occur during the spring and summer months. In the summer, the hours of sunlight are longer and stagnant meteorological conditions can cause reactive pollutants to remain in an area for several days. Occasionally, meteorological conditions can result in stratospheric O_3 being brought down to ground level, a phenomenon known as stratospheric intrusion. The build-up of ozone precursors such as NO_x and hydrocarbons during the winter may also lead to elevated spring O_3 concentrations.

O_3 concentrations tend to be lower in urban locations than rural locations. Cities act as sinks, destroying O_3 that is formed in or near the city. In urban areas, NO emitted from motor vehicles reacts with O_3 to produce NO_2 and molecular oxygen. By contrast, in rural areas with less vehicles, O_3 (produced by the reaction of sunlight with NO_x and natural hydrocarbons or from tropopause folding) is less prone to destruction by NO.

4.8.2 *Method of Monitoring*

O_3 is continuously monitored by either the chemiluminescence or ultra-violet photometry process. The chemiluminescence process involves the reacting of an air sample with ethylene. The reaction of ethylene and O_3 produces light. The intensity of the light produced is proportional to the O_3 concentration. The ultra-violet photometry process uses a mercury vapour lamp as a source of ultra-violet radiation. This method determines the O_3 concentration by the amount of ultra-violet radiation that is absorbed by the O_3 in the sample.

4.8.3 *Regulations and Guidelines*

The regulations governing the maximum permissible concentration of O_3 are based on the prevention of human health effects. Alberta has high natural levels of O_3 and frequently, especially in rural locations, exceeds the 24-hour regulation (Angle and Sandhu 1986). The ambient air quality regulations for O_3 in Alberta are:

- 0.08 ppm as a 1-hour average concentration; and
- 0.025 ppm as a 24-hour average concentration.

4.8.4 *Results*

Ambient concentrations of O_3 were monitored at all three Edmonton and Calgary air monitoring stations as well as Fort Saskatchewan and Fort McMurray in 1990. A frequency distribution of monthly O_3 concentrations and annual average O_3 concentrations for these locations is presented in Figures 4-18 to 4-20.

Average O_3 concentrations reached a maximum during the spring and summer months at all monitoring stations. During the spring and summer months, O_3 production

reaches a maximum due to a peak in incoming solar radiation combined with stagnant meteorological conditions which may cause reactive pollutants to remain in the region for a prolonged period of time. Transport of rural background O_3 to urban locations is also a common cause of high O_3 in Edmonton and Calgary. High daily average O_3 concentrations in the spring may be due to transport of ozone from the upper atmosphere. Annual average O_3 concentrations ranged from 0.014 ppm at the Edmonton and Calgary downtown monitoring units to 0.025 ppm at the Fort Saskatchewan and Fort McMurray monitoring stations. Relatively high annual average O_3 concentrations were also measured at Calgary residential (0.023 ppm) and Edmonton industrial (0.021 ppm) monitoring sites. Lower O_3 concentrations in downtown Edmonton and Calgary are likely due to higher concentrations of NO from motor vehicle emissions which act as a mechanism for O_3 destruction.

A noticeable trend towards higher O_3 concentrations in the afternoon was evident at all monitoring locations. O_3 concentrations tended to increase to a maximum in late afternoon and then drop off to a minimum in the early morning hours. The afternoon peak in O_3 is due to a corresponding peak in incoming solar radiation.

4.8.4.1 Edmonton

The ambient 1-hour average regulation of 0.080 ppm for O_3 was exceeded one and two times, respectively, at the Edmonton residential and industrial monitoring locations. Peak 1-hour average O_3 concentrations of 0.059, 0.081 and 0.082 ppm were observed at the downtown, residential and industrial monitoring stations, respectively. These maximum values were recorded in May at the downtown and residential locations and July at the industrial monitoring station.

The 24-hour average regulation for O_3 of 0.025 ppm was exceeded on numerous occasions at all Edmonton monitoring locations. The 24-hour regulation was exceeded on 24, 71 and 94 days, respectively, at the downtown, residential and industrial monitoring stations, respectively. The highest frequency of exceedances of the 24-hour regulation was observed in May at all Edmonton monitoring stations. About 74% of days recorded 24-hour average O_3 concentrations greater than the regulation at the residential monitoring site in May. The overall maximum 24-hour average O_3 concentration was 0.046 ppm which

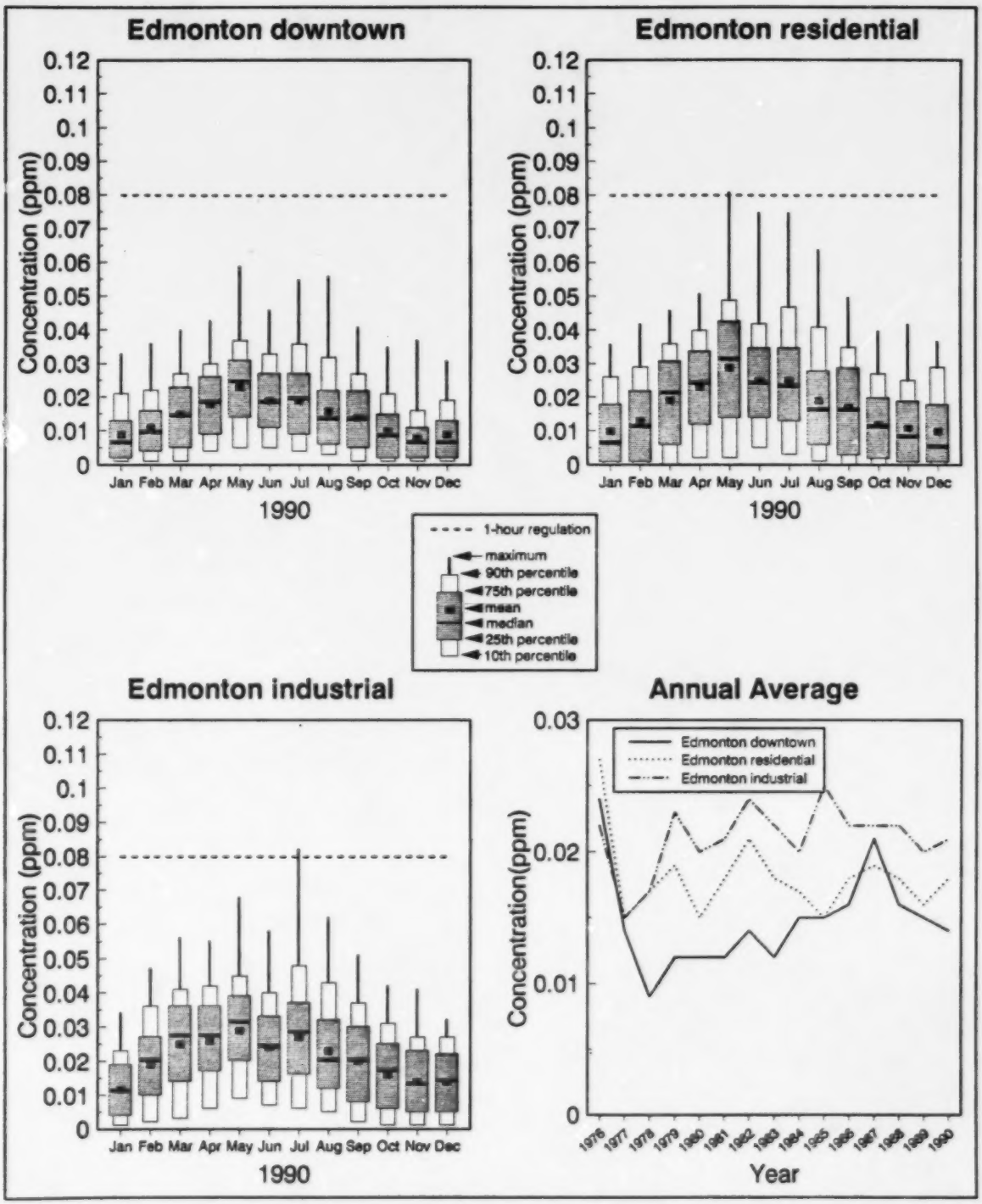

Figure 4-18 Frequency distribution of ozone concentrations at Edmonton.

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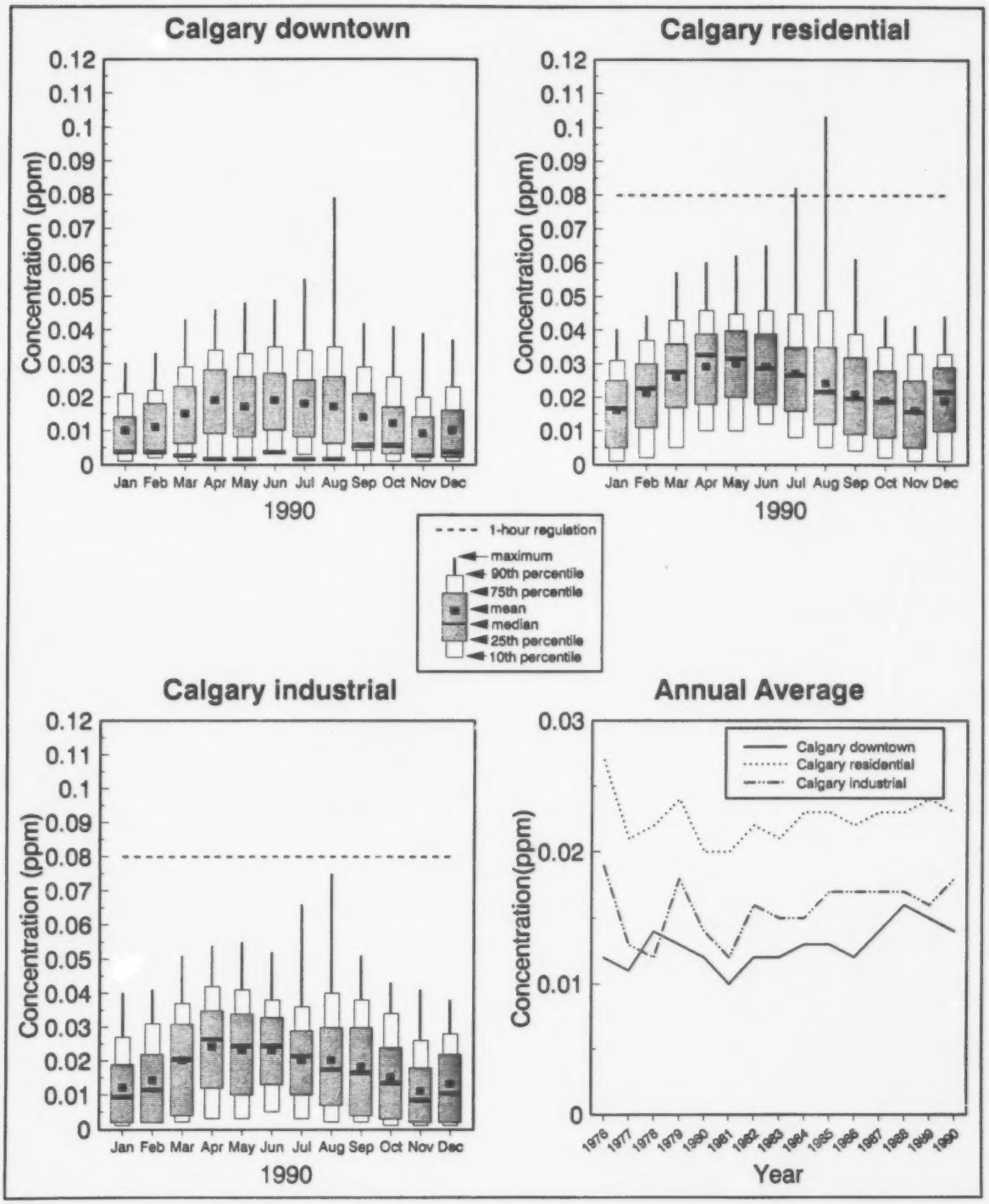

Figure 4-19 Frequency distribution of ozone concentrations at Calgary.

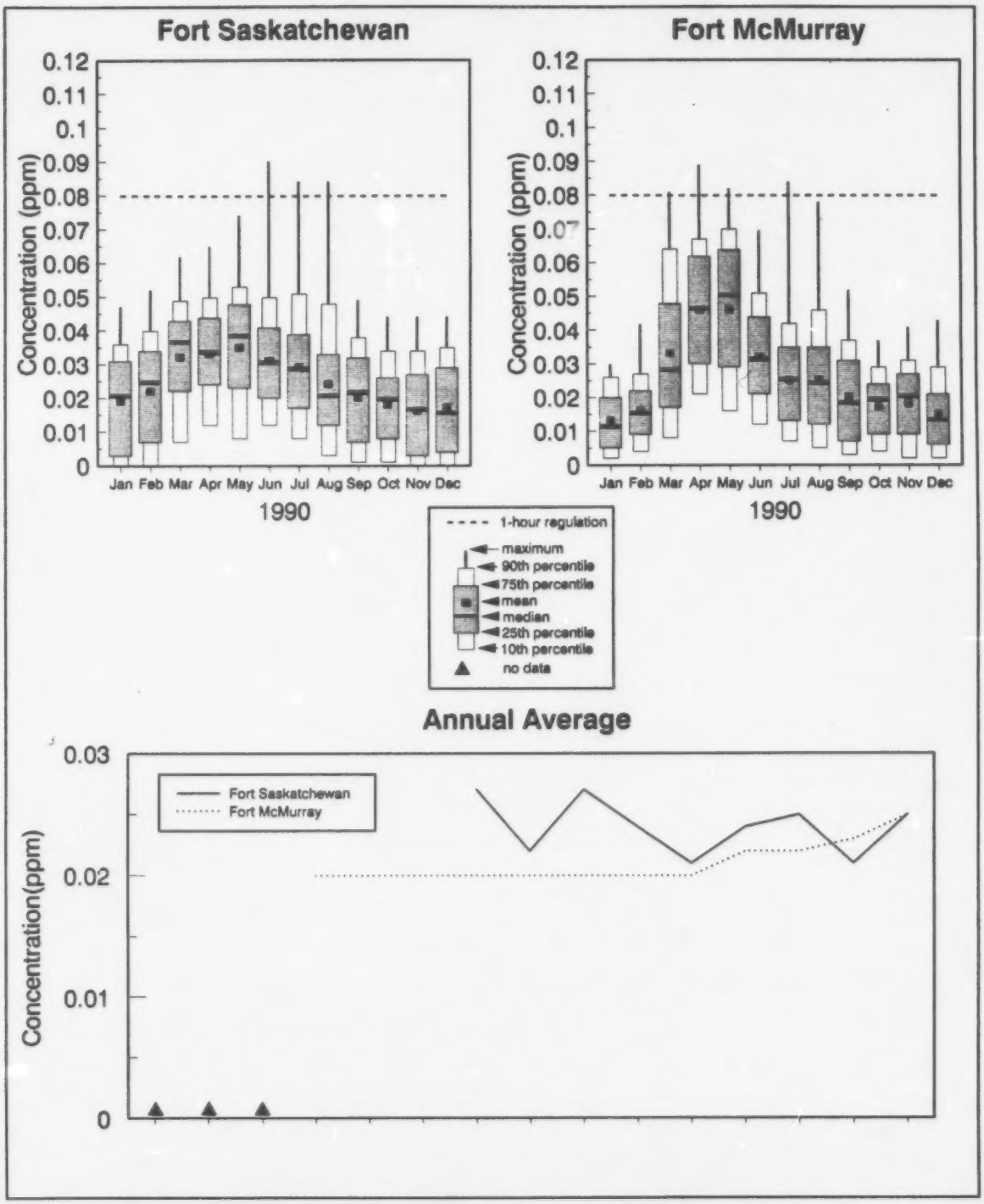

Figure 4-20 Frequency distribution of ozone concentrations at Fort McMurray and Fort Saskatchewan.

occurred at the industrial monitoring location. No significant trends in historical ozone concentrations are detectable at the Edmonton air quality monitoring stations.

4.8.4.2 Calgary

The 1-hour average regulation for O_3 was exceeded on five occasions during the months of July and August at the Calgary residential monitoring location. Peak 1-hour average O_3 concentrations of 0.079, 0.103 and 0.075 ppm were observed at the downtown, residential and industrial monitoring locations, respectively. All of these maximum values occurred in August.

Exceedances of the 24-hour regulation for O_3 were most frequent at the Calgary residential monitoring location. The 24-hour regulation was exceeded on 143 days at the residential monitoring station, 56 days at the industrial monitoring station and 15 days at the industrial monitoring station. The highest frequency of exceedances was in April and May. A maximum frequency of exceedances of 81% was measured during the month of May at the residential monitoring station. The maximum 24-hour average concentration was 0.043 ppm which was recorded at the residential monitoring station. A slight upward trend in O_3 concentration is indicated at the Calgary downtown monitoring station.

4.8.4.3 Fort Saskatchewan

The 1-hour average regulation for O_3 was exceeded on eight occasions during the months of June, July and August at the Fort Saskatchewan monitoring station. The 24-hour regulation was exceeded on 162 days at Fort Saskatchewan. The maximum number of exceedances were observed in May when almost 94% of the days exceeded the regulation. The months of March through June all reported exceedances of the 24-hour regulation greater than 70%. Maximum 1- and 24-hour average values of 0.090 and 0.048 ppm were recorded in June. No significant trend in annual average O_3 concentrations is noted at the Fort Saskatchewan monitoring unit.

4.8.4.4 Fort McMurray

A total of 18 hours exceeded the 1-hour regulation for O_3 at the Fort McMurray monitoring unit in 1990. A maximum 1-hour average of 0.089 ppm was recorded in April at Fort McMurray. The 24-hour average regulation for O_3 was exceeded on 150 days at Fort McMurray. Exceedances of the 24-hour regulation were recorded 100% of the time in April and May. There is a substantial decrease in the frequency of exceedances of the 24-hour regulation in the autumn and winter months. A peak 24-hour average concentration of 0.068 ppm occurred in March. A trend towards higher annual average O_3 concentrations is evident at the Fort McMurray monitoring station.

4.9 SULPHUR DIOXIDE (SO_2)

4.9.1 Characteristics

SO_2 is a heavy, colourless gas with a pungent odour and is designated as a major atmospheric pollutant on a global basis. Processes such as combustion of fossil fuels, smelting and roasting of sulphur containing ores, kraft and sulphite wood pulping, and sour gas processing produce most of the man-made SO_2 in the atmosphere.

In Alberta, during 1988 an estimated 626 kilotonnes of SO_2 were emitted into the atmosphere from man-made sources. About 38% of the SO_2 emissions was contributed by sulphur extraction gas plants; oil sands plants and coal-fired power plants contributed about 29% and 16%, respectively. The remaining 15% was emitted from sources such as gas plant flares, oil refineries, pulp and paper mills and fertilizer plants (Energy Resources Conservation Board, Alberta Energy and Alberta Environment 1990).

4.9.2 Method of Monitoring

SO_2 is monitored continuously by pulsed fluorescence. In this method, air is drawn through a sample chamber where it is irradiated with pulses of ultra-violet light. Any SO_2 in the sample is excited to a higher energy level and upon returning to its original state, light or fluorescence is released. The amount of fluorescence measured is proportional to the SO_2 concentration.

4.9.3 *Regulations and Guidelines*

The regulations governing the maximum permissible concentration of SO_2 are based on preventing damage to vegetation. At these levels, no known health effects are detectable. In regulating SO_2, Alberta has adopted Environment Canada's most rigorous ambient regulation:

- 0.17 ppm as a 1-hour average concentration;
- 0.06 ppm as a 24-hour average concentration; and
- 0.01 ppm as an annual arithmetic concentration.

4.9.4 *Results*

SO_2 was monitored on a continuous basis at Edmonton and Calgary industrial locations; and at Fort Saskatchewan, Fort McMurray and Fort MacKay. Figures 4-21 to 4-23 show monthly frequency distributions and annual averages of SO_2 at these monitoring locations. Annual average SO_2 concentrations ranged from 0.002 ppm at Fort Saskatchewan to 0.003 ppm at all the other stations which monitor SO_2. These values are substantially lower than the standard of 0.010 ppm as an annual average for SO_2. SO_2 concentrations tend to be greater during the winter months due to meteorological conditions such as persistent inversions which do not allow pollutants to disperse rapidly. A well-defined diurnal trend in SO_2 is not evident. Annual average SO_2 concentrations are not high enough to resolve a significant trend.

4.9.4.1 *Edmonton*

The 1-hour, 24-hour and annual average SO_2 regulations were not exceeded at the Edmonton industrial monitoring location. The peak 1- and 24-hour average SO_2 concentrations observed were 0.056 ppm and 0.011 ppm, respectively.

4.9.4.2 *Calgary*

The maximum observed 1-hour average SO_2 concentration at the Calgary industrial monitoring station was 0.041 ppm. This value is 24% of the 1-hour average regulation for SO_2. The 24-hour regulation for SO_2 was not exceeded at the industrial

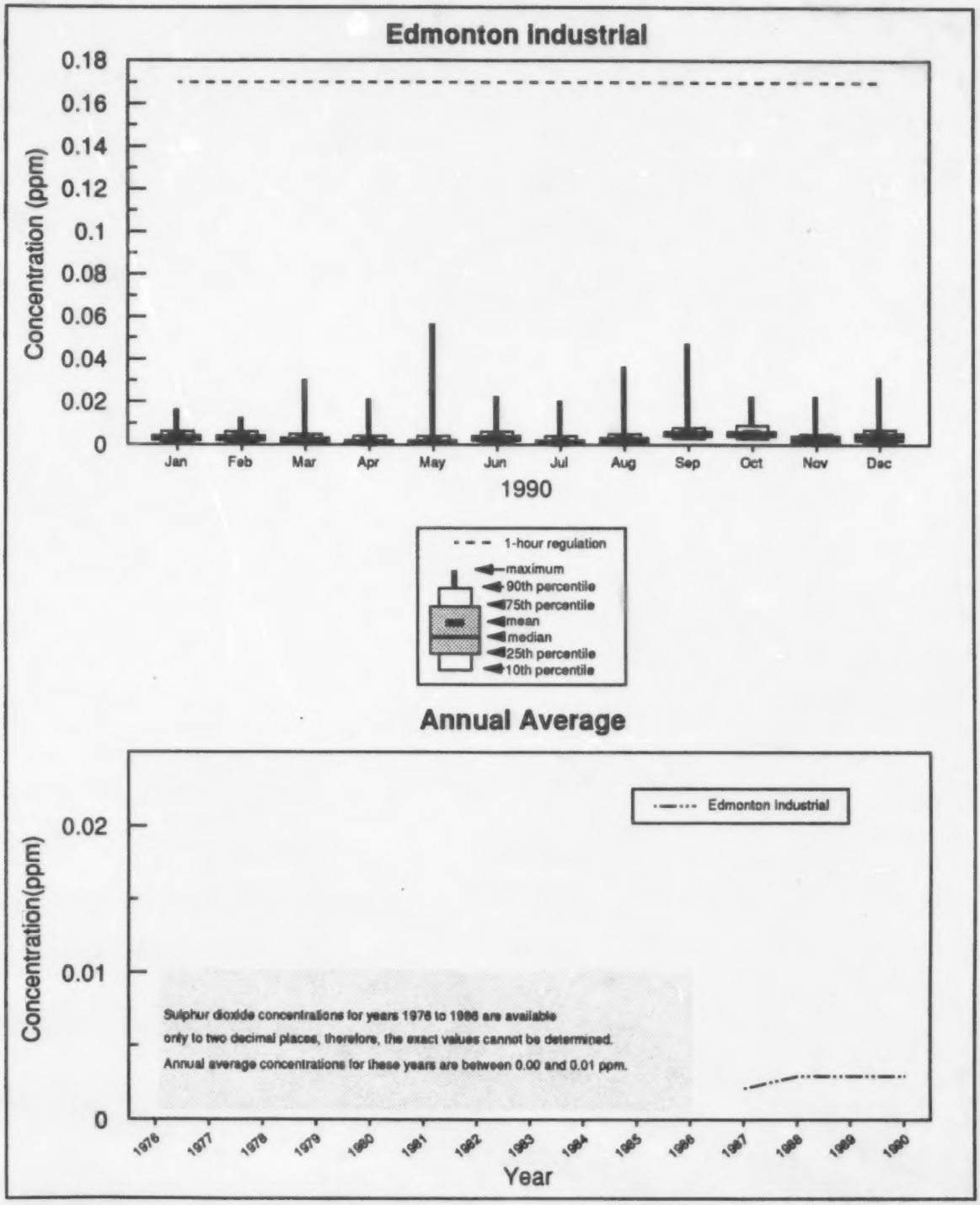

Figure 4-21 Frequency distribution of sulphur dioxide concentrations at Edmonton.

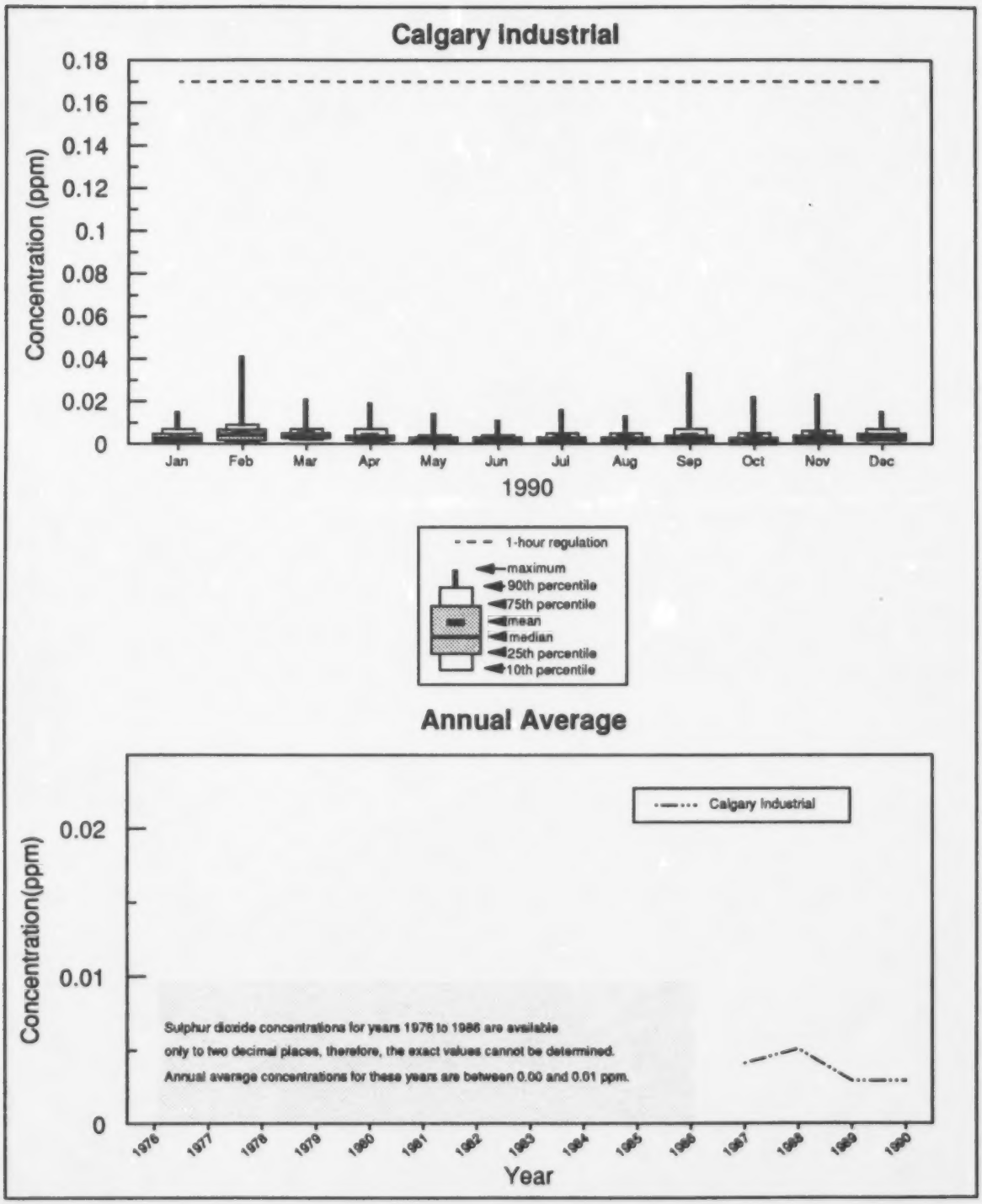

Figure 4-22 Frequency distribution of sulphur dioxide concentrations at Calgary.

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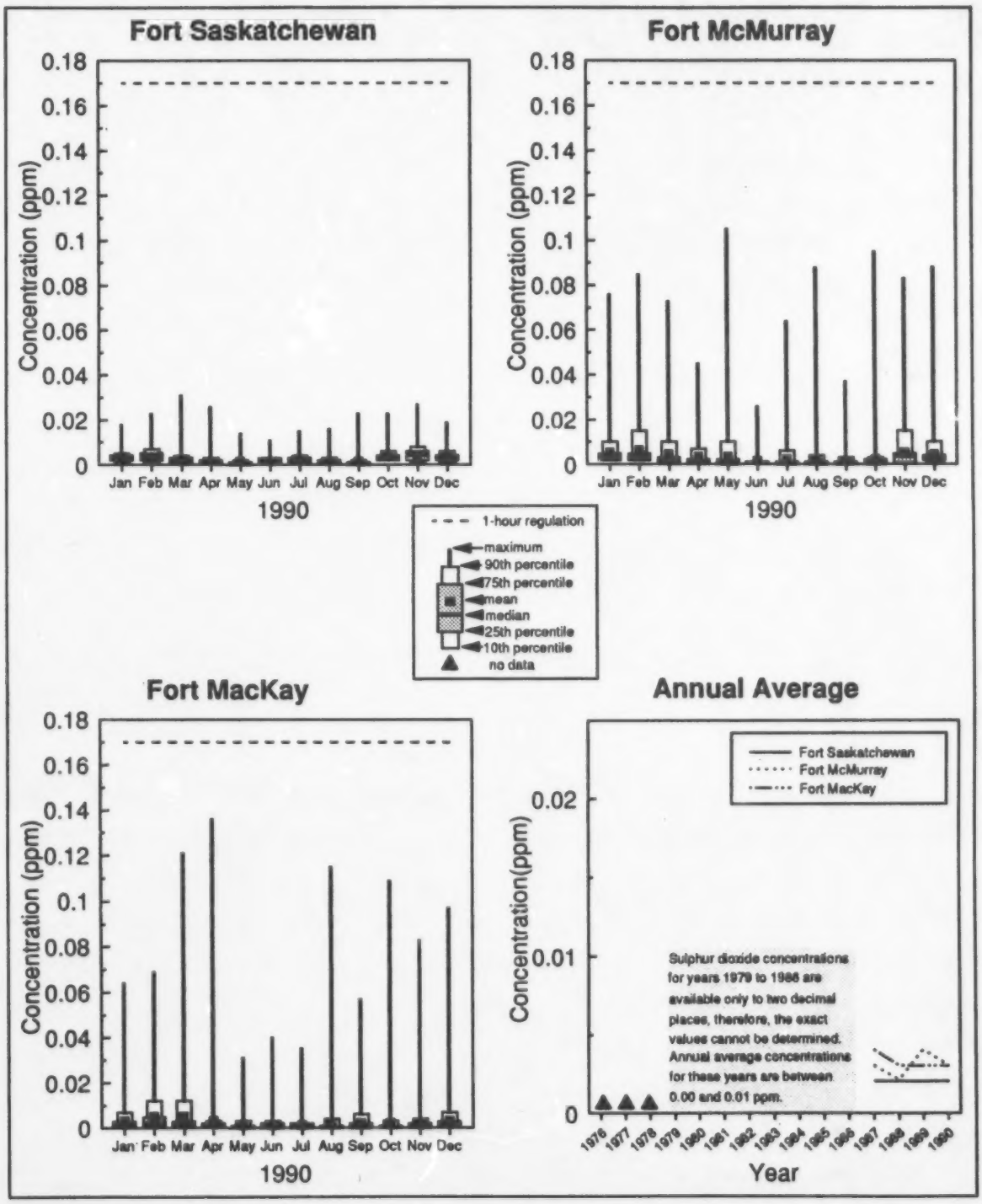

Figure 4-23 Frequency distribution of sulphur dioxide concentrations at Fort Saskatchewan, Fort McMurray and Fort MacKay.

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monitoring station in 1990. The peak 24-hour average concentration recorded at the industrial location was 0.012 ppm.

4.9.4.3 Fort Saskatchewan

Regulations for SO_2 were not exceeded at the Fort Saskatchewan monitoring unit in 1990. The maximum 1- and 24-hour average SO_2 concentrations were 0.031 and 0.009 ppm, respectively.

4.9.4.4 Fort McMurray and Fort MacKay

The regulations for SO_2 were not exceeded at the Fort McMurray or Fort MacKay monitoring units. Maximum 1-hour average SO_2 concentrations recorded at these locations were 0.105 and 0.136 ppm, respectively. These values are 62% and 80% of the 1-hour regulation for SO_2, respectively. Maximum 24-hour average values at Fort McMurray and Fort MacKay were 0.025 and 0.028 ppm, respectively.

4.10 TOTAL HYDROCARBONS (THC)

4.10.1 Characteristics

The term "total hydrocarbons" refers to the combined concentration of two broad categories of organic compounds: reactive and non-reactive hydrocarbons. The non-reactive component is primarily methane, a colourless, odourless gas that is naturally present in the atmosphere at concentrations of about 1.5 ppm. The reactive component is essentially organic compounds other than methane that are usually present in much lower concentrations. Reactive hydrocarbons are especially important because they will react with nitrogen oxides in the presence of sunlight to form ozone.

Natural sources of hydrocarbons include trees and other vegetation, and the decay of animal and plant material. The primary man-made sources of hydrocarbons are motor vehicles, gasoline marketing tanks and storage tanks. Smaller amounts of hydrocarbons are emitted by sources such as the petroleum and chemical industries, drycleaning, fireplaces, natural gas combustion and aircraft traffic. Motor vehicle emissions of hydrocarbons are the result of inefficient combustion.

4.10.2 Method of Monitoring

Hydrocarbons are monitored continuously by a hydrogen flame ionization detector. When burned, carbon-hydrogen bonds break creating ions that conduct an electric current. This current is then measured by an electrometer to give a signal proportional to the number of ions.

4.10.3 Regulations and Guidelines

Alberta currently has no ambient air quality regulations for hydrocarbons.

4.10.4 Results

Hydrocarbons were monitored at all Alberta Environment continuous air quality stations in 1990. Frequency distributions of these values are illustrated in Figures 4-24 to 4-26. These figures also show annual average THC concentrations. Annual average THC concentrations ranged from 1.6 to 2.2 ppm. The lowest annual average concentrations were recorded at the Edmonton industrial and Fort McMurray monitoring units while the highest concentration was monitored at the Edmonton residential monitoring location.

Hydrocarbon concentrations were generally highest in the winter months due to an increased frequency of inversions which inhibit the dispersion of pollutants. Relatively high THC concentrations were also observed in the fall at the Edmonton downtown monitoring site. The exception to this was Fort MacKay where the maximum THC concentrations were recorded in the spring season. At urban locations, such as Edmonton and Calgary, the predominant source of reactive hydrocarbons was automobile emissions.

Significant diurnal trends of THC were noted at air quality monitoring stations which are located within close proximity of major traffic arteries. Diurnal trends were especially evident during the winter months at the Edmonton downtown, Edmonton residential, Calgary downtown, Calgary industrial and Fort Saskatchewan monitoring stations.

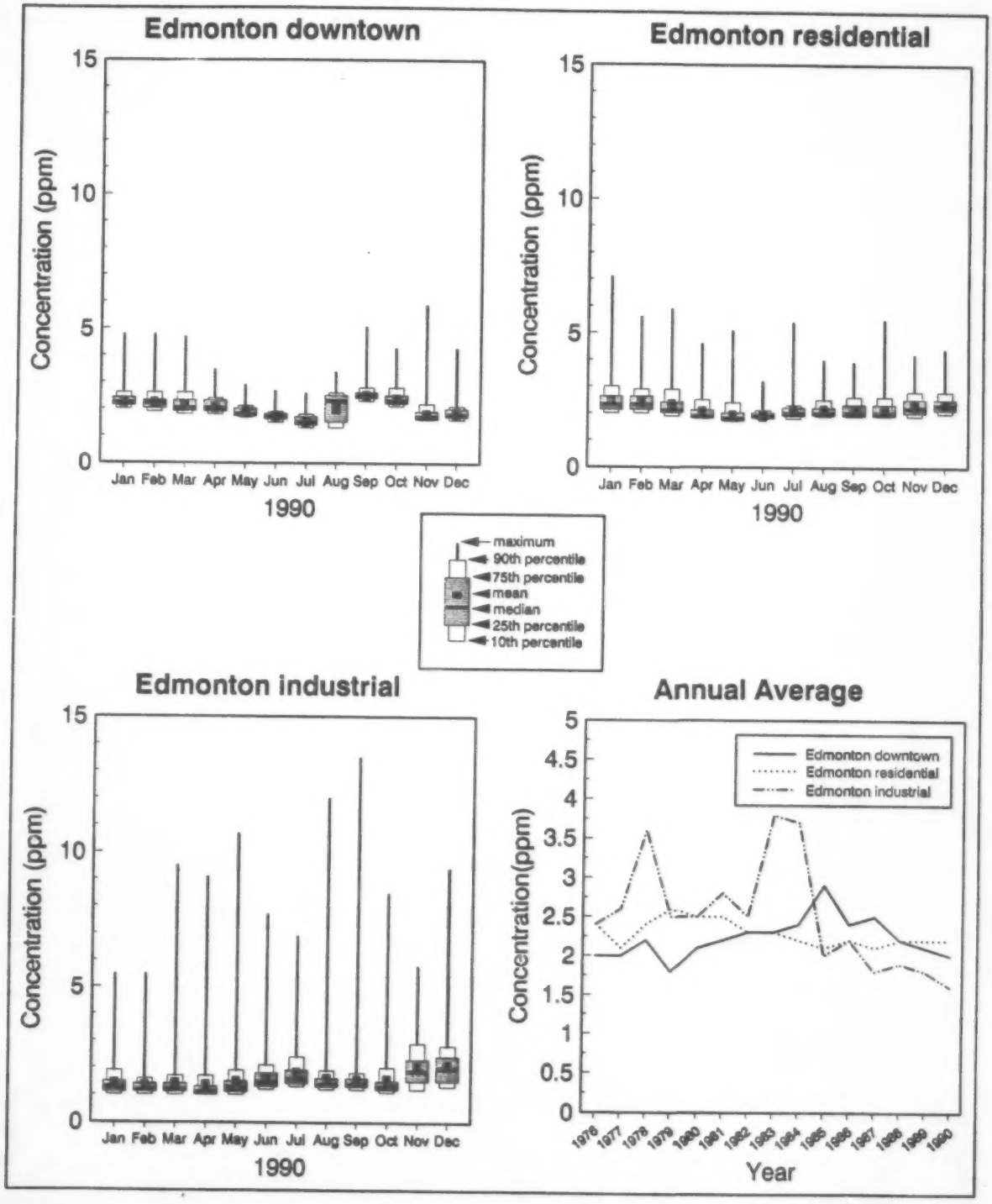

Figure 4-24 Frequency distribution of total hydrocarbon concentrations at Edmonton.

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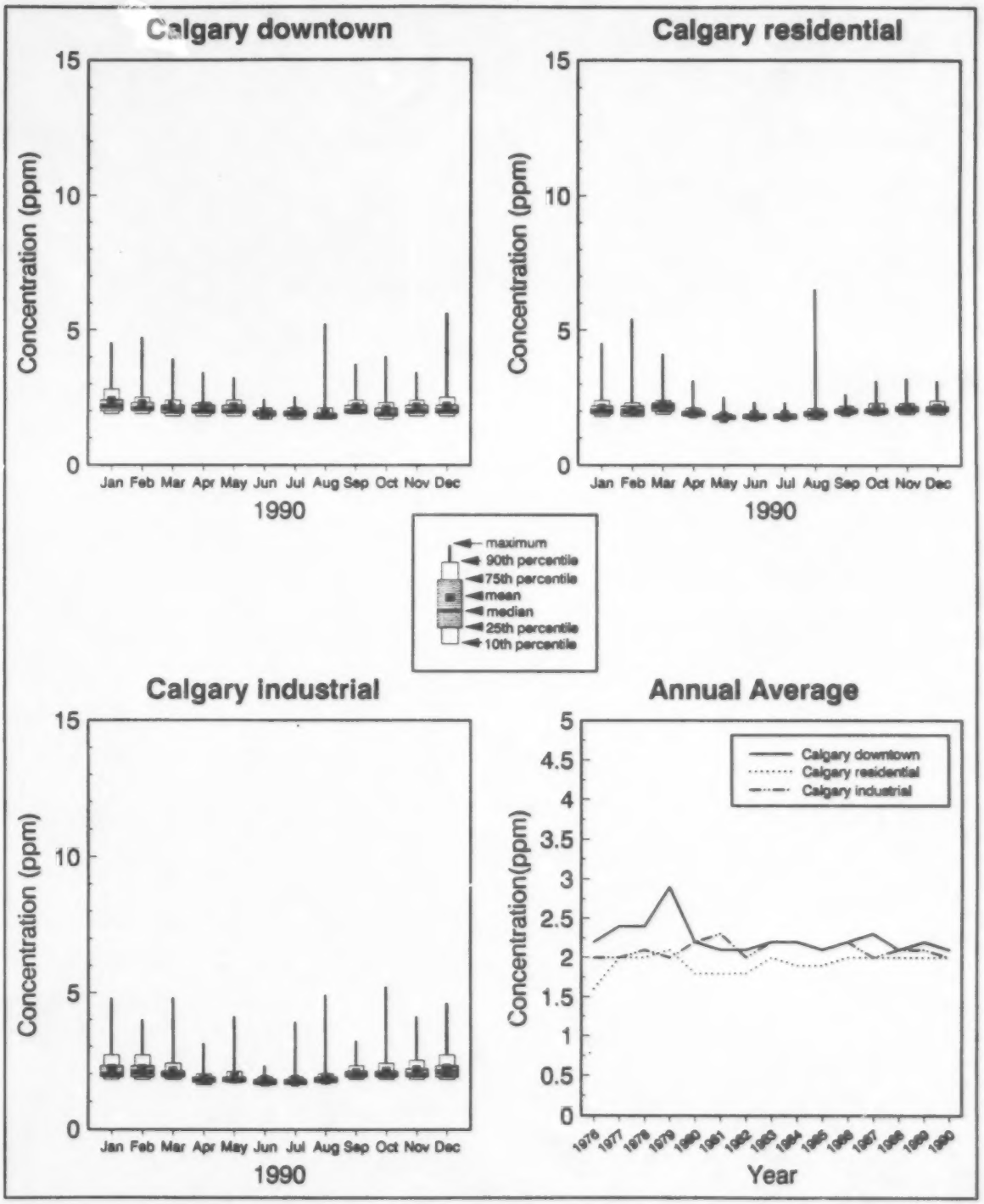

Figure 4-25 Frequency distribution of total hydrocarbon concentrations at Calgary.

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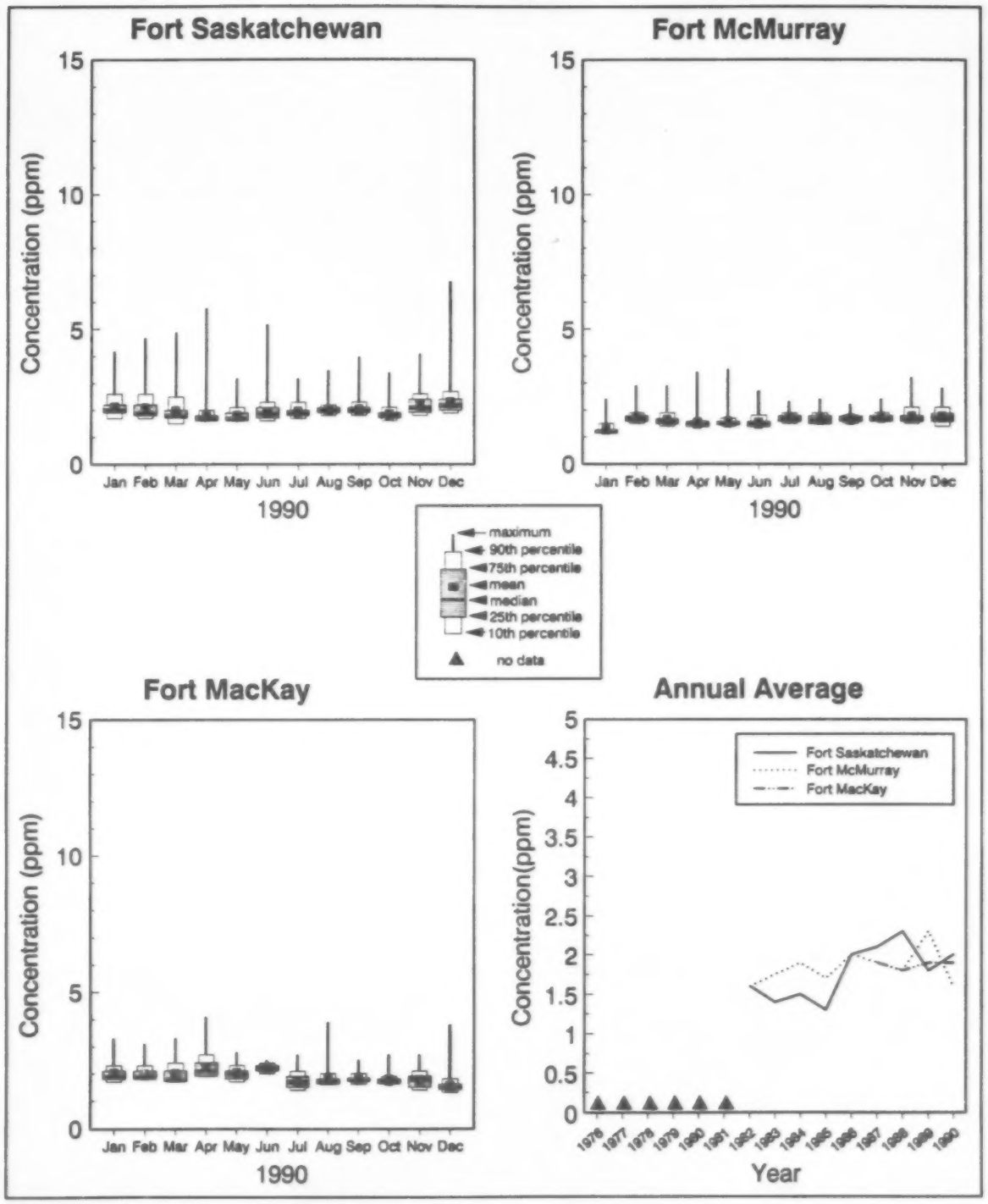

Figure 4-26 Frequency distribution of total hydrocarbon concentrations at Fort Saskatchewan, Fort McMurray and Fort MacKay.

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4.10.4.1 Edmonton

Maximum 1-hour average THC concentrations ranged from 5.9 ppm at the downtown monitoring station to 13.5 ppm at the industrial monitoring location. Maximum concentrations were generally observed in the winter and fall at Edmonton monitoring stations although, fairly high THC concentrations were also evident in the spring at the industrial monitoring station. Relatively high THC concentrations observed in the industrial region were likely due to fugitive emissions originating from petrochemical storage tanks and transportation vehicles. A slight decrease in annual average THC concentrations was shown at the Edmonton industrial monitoring location.

4.10.4.2 Calgary

Maximum 1-hour THC concentrations ranged from 5.2 ppm at the industrial monitoring unit to 6.5 ppm at the residential monitoring unit. These values occurred in January at both monitoring stations. Maximum THC concentrations were recorded in December, August and October at the downtown, residential and industrial monitoring stations, respectively. A significant increase in annual THC concentrations is evident at the residential monitoring station.

4.10.4.3 Fort Saskatchewan

The maximum 1-hour average THC concentrations observed at the Fort Saskatchewan monitoring unit was 6.8 ppm, recorded in December. Relatively high maximum THC concentrations were also recorded in April (5.8 ppm) and June (5.2 ppm). Annual average THC values do not indicate a trend at Fort Saskatchewan.

4.10.4.4 Fort McMurray and Fort MacKay

Maximum 1-hour average THC concentrations of 3.5 and 4.1 ppm were measured, respectively, at Fort McMurray and Fort MacKay. These values were recorded in May and April, respectively. The highest peak THC values are generally observed in the winter and spring at the Fort McMurray and Fort MacKay monitoring stations. A trend of THC concentrations is not evident at these two stations.

5. INTERMITTENT MONITORING RESULTS

Data analysis has been conducted on intermittent air quality data to resolve, on a monthly basis, the maximum, minimum and mean loadings of specified parameters. A trend analysis was also performed on annual average parameter loadings using Daniel's trend test. This test is described in Section 4.

5.1 TOTAL SUSPENDED PARTICULATES (TSP)

5.1.1 Characteristics

Air pollutants are not only in the gaseous form. Tiny particles of solid material or liquid droplets, defined collectively as particulates, are also present in the air in great numbers, and may constitute an air pollution problem. The particles range in size from 0.001 to 500 microns (a human hair is about 100 microns in diameter) and, depending on their size and other properties, may remain suspended in the air for a few seconds or indefinitely.

In general, particles smaller than one micron in diameter originate in the atmosphere principally through condensation and combustion. Particles between 1 micron and 10 microns in diameter usually include soil, process dusts, and combustion products from industries. Particles larger than 10 microns in diameter generally result from mechanical processes such as wind erosion, grinding, spraying and vehicular activity.

Suspended particulates may result from a variety of natural and man-made sources. These include soil, road dust, dust resulting from other human activities (i.e., agriculture), smoke from forest fires, smoke from recreational sources (i.e., camp fires and fireplaces), vehicular exhaust emissions, and industrial emission sources.

5.1.2 Method of Monitoring

Suspended particulate matter is measured by the high-volume sampler. The sampler consists of a vacuum system and filter housed in a shelter and operates on the same principle as a vacuum cleaner. The TSP matter in the atmosphere is collected by drawing a known volume of air through a pre-weighed filter for a 24-hour period every sixth day

according to the NAPS monitoring schedule. The filter is then reweighed to determine the mass of the particles collected.

5.1.3 Regulations and Guidelines

Regulations governing the maximum permissible levels of TSP are based on visibility reduction and nuisance effects. Alberta has adopted the most rigorous federal standards for maximum TSP loadings:

- 100 ug/m^3 (micrograms per cubic meter) as a 24-hour total loading; and
- 60 ug/m^3 as an annual geometric mean loading.

5.1.4 Results

In 1990, suspended particulates were monitored at all three Edmonton and Calgary monitoring stations, and at Fort Saskatchewan and Ellerslie monitoring locations. Mean, maximum and minimum TSP loadings are presented by month in Figures 5-1 to 5-3. Annual average loadings of TSP ranged from 22.0 ug/m^3 at Ellerslie to 73.9 ug/m^3 at the Calgary industrial monitoring location. Suspended particulate loadings were much lower at Fort Saskatchewan and Ellerslie than at the urban locations of Edmonton and Calgary.

5.1.4.1 Edmonton

Exceedances of the 24-hour regulation occurred at all Edmonton monitoring stations. The highest frequency of exceedances was recorded at the downtown monitoring station due to a greater traffic density than the residential and industrial monitoring locations. Most exceedances are recorded in the winter and spring at Edmonton monitoring stations. This may be due to meteorological conditions in the winter which do not allow pollutants to disperse rapidly and resultant sand and dust which is evident on most streets after spring thaw. A peak 24-hour total TSP loading of 188.4 ug/m^3 was observed at the Edmonton downtown monitoring unit in April. The annual average regulation for TSP of 60 ug/m^3 was exceeded at the downtown monitoring location. An annual average TSP loading of 63.2 ug/m^3 was recorded at this location. A slight decrease in annual average TSP loading is indicated at the residential monitoring station.

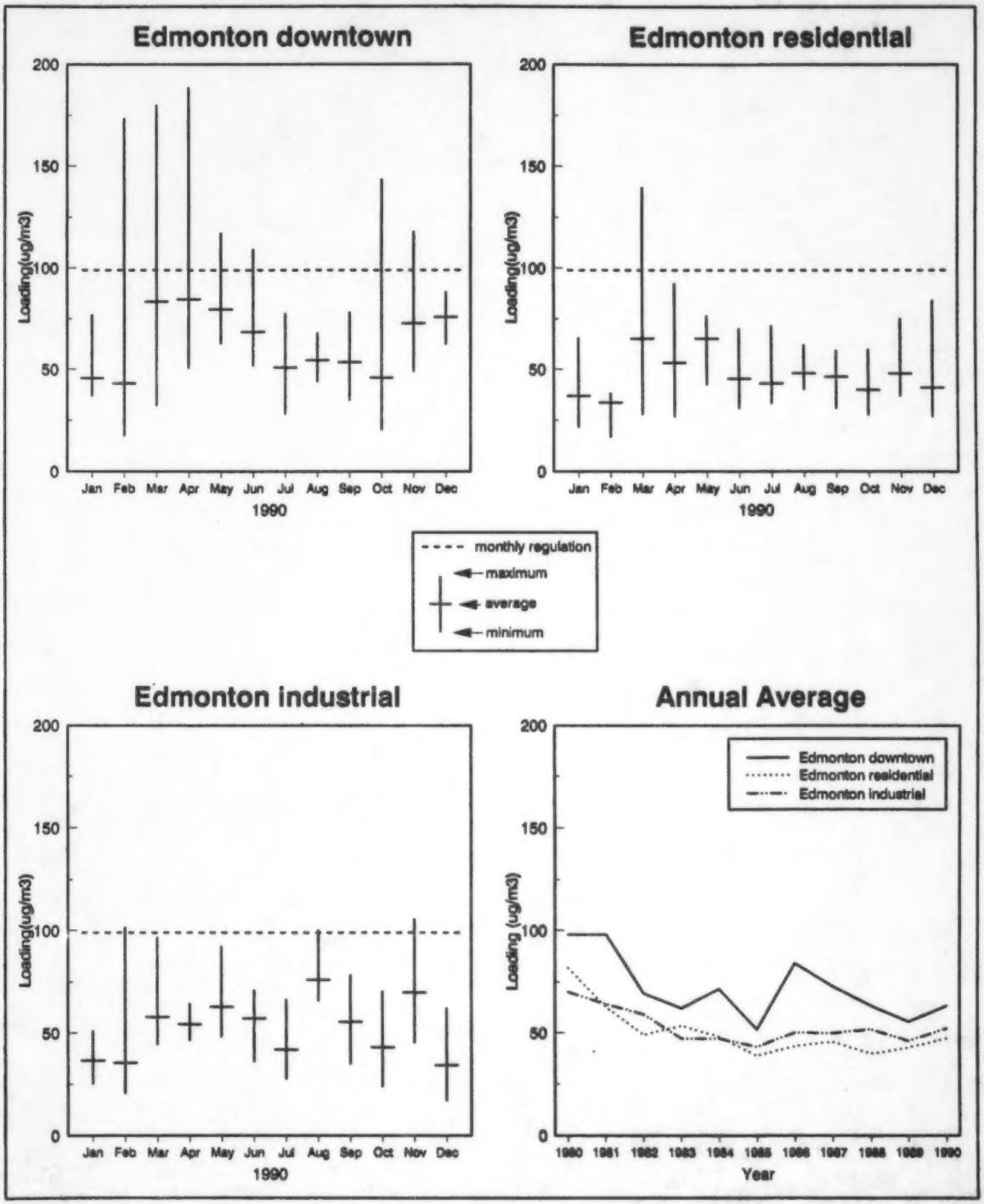

Figure 5-1 Total suspended particulate loadings at Edmonton.

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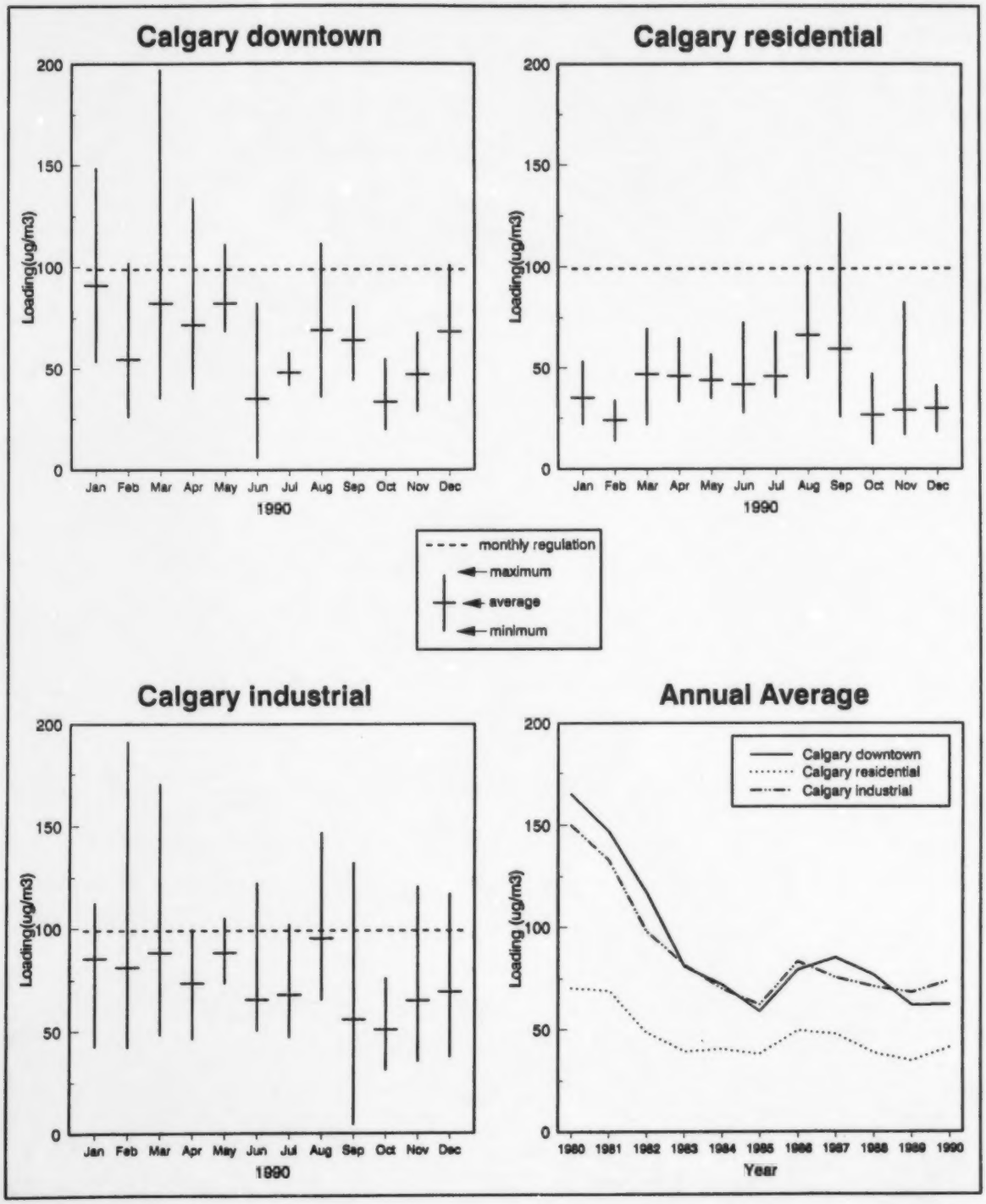

Figure 5-2 Total suspended particulate loadings at Calgary.

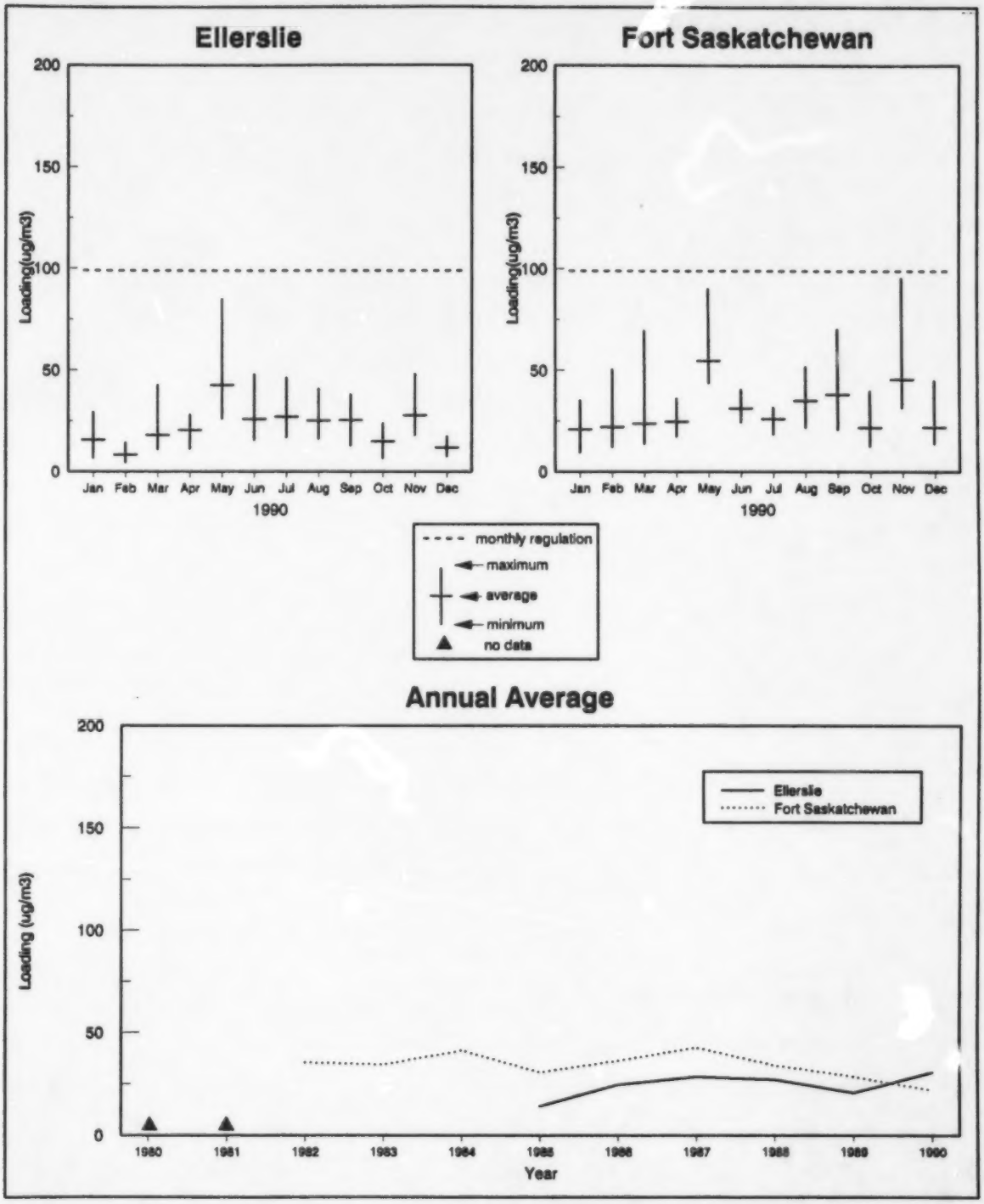

Figure 5-3 Total suspended particulate loadings at Ellerslie and Fort Saskatchewan.

5.1.4.2 Calgary

Exceedances of the 24-hour regulation for TSP were exceeded frequently at the downtown and industrial monitoring locations. One exceedance was recorded at the residential monitoring unit. Exceedances were observed in 40% of the observations during January at the downtown location and during January, March, August and September at the industrial monitoring unit. The maximum TSP loading observed in Calgary was 200.0 ug/m^3 which occurred in March at the downtown monitoring location. The annual average regulation was also exceeded at the Calgary downtown and industrial monitoring stations. Annual average TSP loadings of 62.4 and 73.9 ug/m^3 were recorded at these two locations, respectively. A significant decrease in annual average total suspended particulate loadings is evident at the Calgary downtown monitoring stations. A slight decrease is also evident at the residential and industrial monitoring stations.

5.1.4.3 Fort Saskatchewan and Ellerslie

The 24-hour regulation for TSP loading was not exceeded at the Fort Saskatchewan and Ellerslie high-volume monitoring stations in 1990. Maximum TSP loadings of 95.3 and 84.8 ug/m^3 were measured at Fort Saskatchewan and Ellerslie, respectively. On average, the highest TSP values are recorded in the spring, summer and fall at Fort Saskatchewan and Ellerslie. Higher values in these seasons may be attributed to road and agricultural dust. A trend in annual average TSP loadings is not detectable at Ellerslie or Fort Saskatchewan.

5.2 BENZO (a) PYRENE (BaP)

5.2.1 Characteristics

BaP is an organic compound that belongs to a class of compounds known as polycyclic aromatic hydrocarbons (PAH). BaP is formed during the combustion of organic materials and is present in all types of soot and smoke. The prime sources are heat and power generation, refuse burning, coke production and motor vehicle emissions. BaP has also been detected in tobacco smoke, wood smoke from fireplaces and forest fires.

Most sources of BaP have not been accurately characterized because of the variety of factors that influence BaP formation. For example, during the process of combustion, the amount of excess air, combustion temperature, fuel moisture content and feed conditions will affect the formation of BaP.

5.2.2 *Method of Monitoring*

BaP loadings are obtained by chemical analysis of high-volume sampler filters. The result is a 24-hour accumulated loading of BaP expressed in micrograms per 1000 cubic meters (ug/1000 m^3).

5.2.3 *Regulations and Guidelines*

Alberta Environment does not currently have regulations or guidelines for ambient loadings of BaP.

5.2.4 *Results*

BaP was monitored at all three Edmonton and Calgary air quality monitoring stations as well as at the Fort Saskatchewan and Ellerslie monitoring units. A distinct seasonal trend in BaP loadings was apparent at all monitoring locations. Much higher loadings of BaP were evident in the fall and winter than in the other seasons of the year. Relatively low BaP loadings were observed in the summer months at all stations. During the winter, meteorological conditions that retard the dispersion of pollutants, such as inversions and low wind speeds, tend to be more prevalent. A second contributing factor is that automobile engines run less efficiently during cold temperatures which leads to an increase in BaP emissions from automobiles.

Annual average BaP loadings ranged from 0.01 ug/1000 m^3 at Ellerslie to 0.27 ug/1000 m^3 at the Edmonton downtown monitoring unit. Annual average BaP loadings are much higher at monitoring stations located in the vicinity of heavily used traffic arteries. Minimum, maximum and mean BaP loadings are presented in Figures 5-4 to 5-6 for each monitoring station.

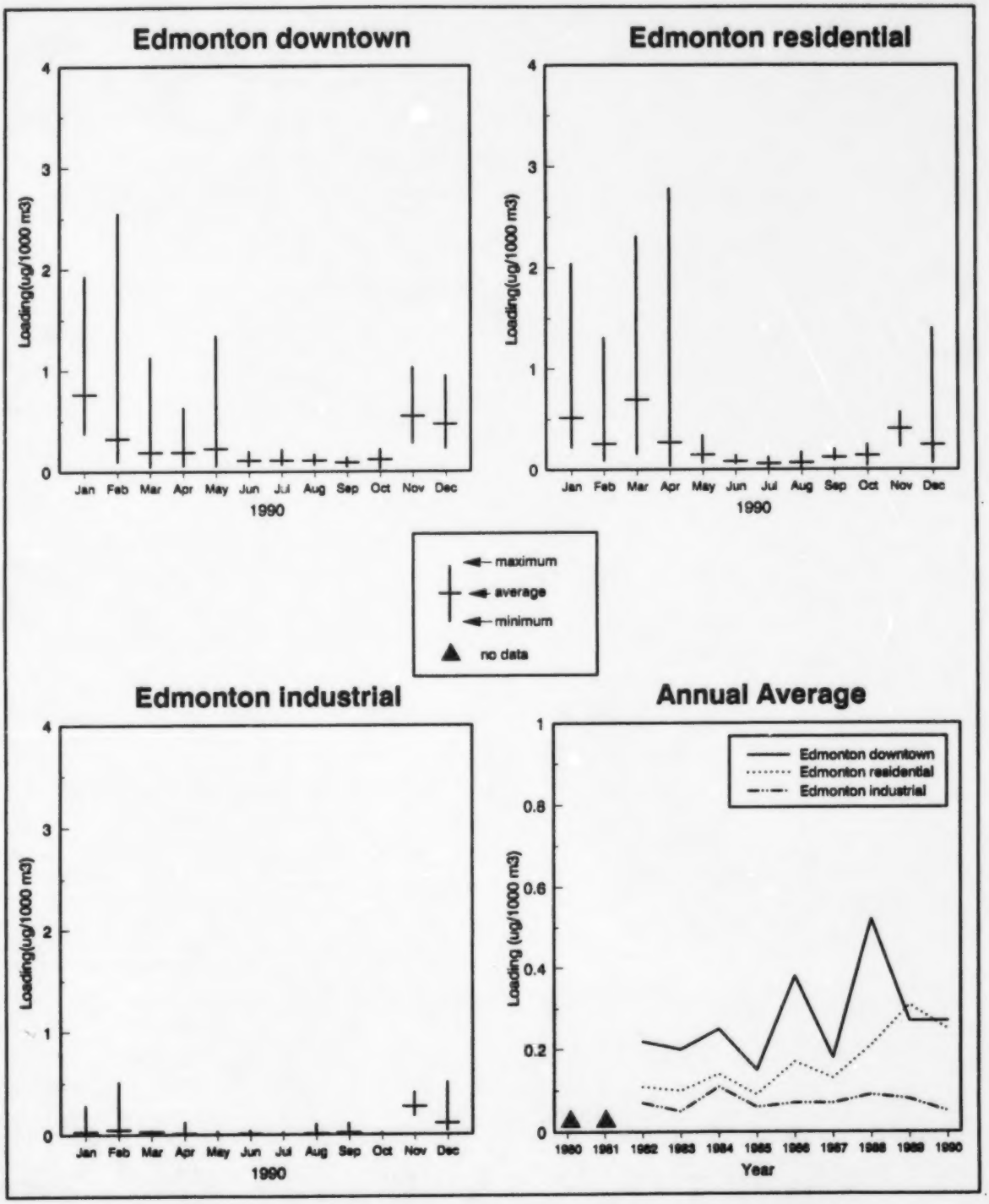

Figure 5-4 Benzo (a) Pyrene loadings at Edmonton.

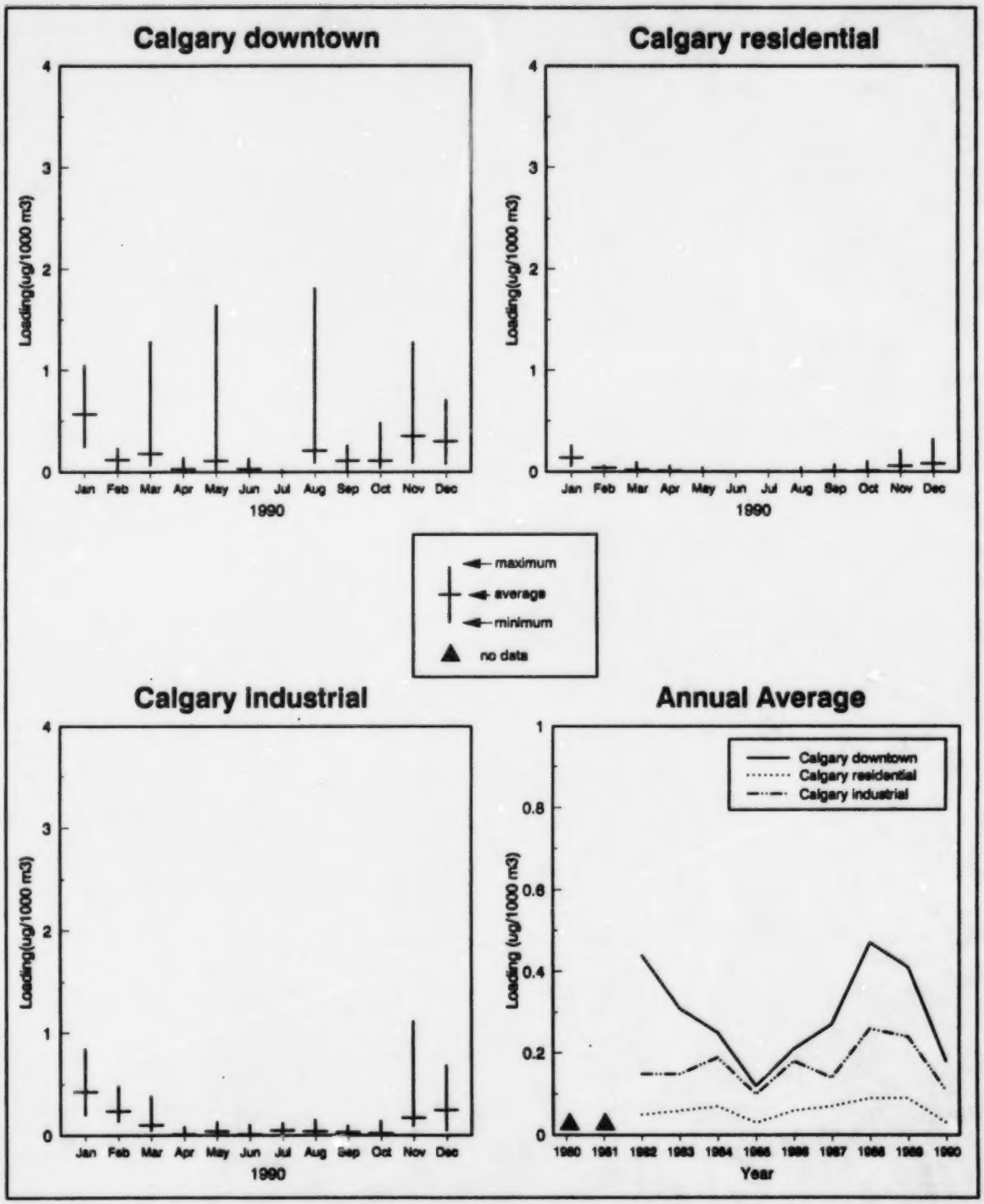

Figure 5-5 Benzo (a) Pyrene loadings at Calgary.

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Environmental Quality Monitoring Branch

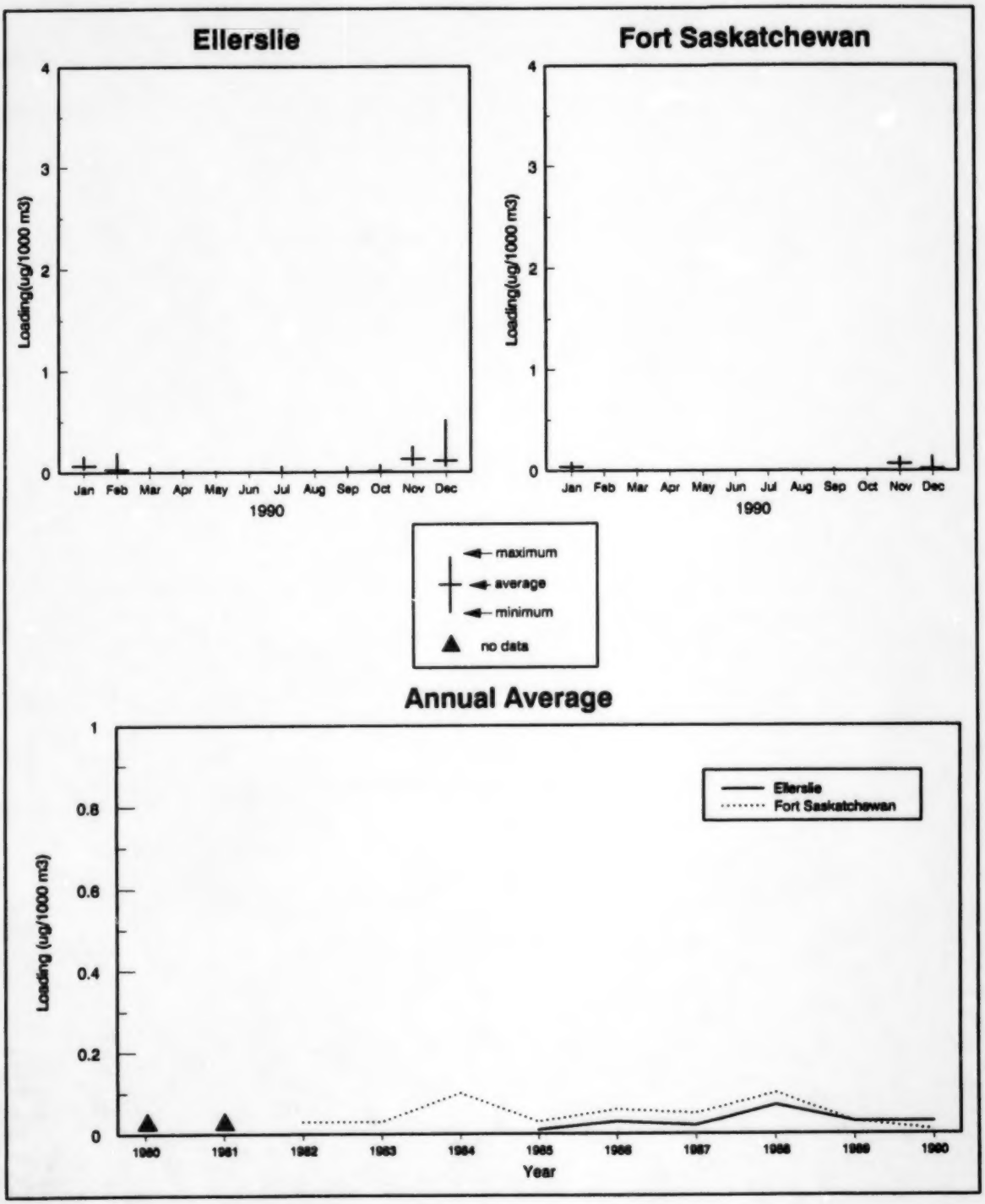

Figure 5-6 Benzo (a) Pyrene loadings at Ellerslie and Fort Saskatchewan.

5.2.4.1 *Edmonton*

Higher BaP loadings were observed at the downtown and residential monitoring stations than at the industrial monitoring location. The downtown and residential stations are located in the vicinity of major traffic arteries. Vehicular emissions are a major source of BaP. A maximum BaP loading of 2.8 ug/1000 m^3 was observed in April at the Edmonton residential monitoring station. BaP has shown a significant increase in annual average loadings over the last nine years at the Edmonton residential monitoring location. This increase is likely due to an increase in vehicle traffic in the region.

5.2.4.2 *Calgary*

BaP loadings at the Calgary downtown monitoring station were substantially higher than those recorded at the residential and industrial monitoring stations. Relatively high BaP loadings were also recorded at the industrial monitoring location. Vehicular traffic in downtown Calgary is likely the major source of BaP at this location. Vehicle traffic on Deerfoot trail, which is located to the east of the industrial monitoring station, is likely the major contibutor to elevated BaP values at the industrial station. A peak BaP loading of 1.81 ug/1000 m^3 was recorded in August at the Calgary downtown monitoring location. A slight trend towards higher BaP loadings is evident at the residential monitoring station.

5.2.4.3 *Fort Saskatchewan and Ellerslie*

BaP loadings at Fort Saskatchewan and Ellerslie were much lower than at the downtown stations of Edmonton and Calgary. Maximum BaP loadings at Fort Saskatchewan and Ellerslie were 0.51 ug/1000 m^3 and 0.14 ug/1000 m^3, respectively. These values occurred in December at both monitoring stations.

5.3 LEAD (Pb)

5.3.1 Characteristics

Lead in the ambient air exists primarily as particulate matter of inhalable size. Atmospheric lead results predominantly from man-made processes such as the operation of motor vehicles, iron and steel production, solid waste incineration and battery manufacturing. The burning of leaded gasoline by motor vehicles was the largest source of lead in the atmosphere. Lead is emitted from vehicle exhaust in the form of lead vapours, lead alkyls, very fine lead particles and organic halogens such as lead bromide, lead chloride and lead bromochloride. These compounds originate from the lead anti-knock additives used in gasoline.

In Canada, automobile emissions of lead have steadily increased from 2600 tonnes in 1948 to a peak of 14,360 tonnes in 1973. The introduction of unleaded gasoline coupled with restrictions on the lead content in leaded gasoline has resulted in a general decrease in the quantity of lead emitted into the atmosphere.

The next phase in reducing lead levels in leaded gasoline took place on January 1, 1987 when the amount of lead added to gasoline was reduced by one-third. Since September 1987 all new model light-duty vehicles were required to be equipped with catalytic converters which allow only the use of unleaded fuel.

5.3.2 Method of Monitoring

Lead is monitored every sixth day at all high-volume monitoring stations according to the NAPS monitoring schedule. High-volume filters undergo laboratory analysis to quantify the amount of lead in the sample.

5.3.3 Regulations and Guidelines

Alberta currently regulates lead emissions by licencing each source and limiting their emissions according to the Clean Air (Maximum Levels) Regulation.

5.3.4 *Results*

Lead was monitored at all high-volume monitoring stations in 1990. Lead loadings were substantially greater at monitoring stations located close to areas with a high traffic density. Annual average lead loadings ranged from 0.02 ug/m^3 at Ellerslie to 0.14 ug/m^3 at the Calgary industrial monitoring station. Seasonal trends in lead loadings were detected, to some extent, at all monitoring stations. Although lead loadings generally drop tc a minimum in the summer months, some exceptions to this trend do occur. High winter lead loadings are due to an increased frequency of meteorological conditions that inhibit the dispersion of pollutants, increased idling times by motor vehicles, and decreased vehicle engine efficiency. A general decrease in annual average lead loadings is evident from 1989 to 1990. This trend may reflect the suspended sale of leaded gasoline at gas stations in 1990. Figures 5-7 to 5-9 show the mean, maximum and minimum lead loadings by month at each of the monitoring stations.

A long-term trend towards lower lead loadings is indicated at all monitoring stations except at Ellerslie. This is a reflection of a substantial decrease of lead additives in gasoline over the past 10 years.

5.3.4.1 *Edmonton*

Average lead loadings were generally greater at the Edmonton downtown and residential monitoring stations than at the industrial monitoring station. Peak lead loadings at the downtown, residential and industrial monitoring stations were 0.39, 0.51 and 0.26 ug/m^3, respectively. These peak values were measured in February at all Edmonton monitoring stations. Relatively high lead loadings at the downtown and residential monitoring locations were due to high traffic densities in the vicinity of these two locations.

5.3.4.2 *Calgary*

Maximum lead loadings at the Calgary monitoring stations were 0.61 (downtown), 0.41 (residential) and 0.81 ug/m^3 (industrial). All peak values occurred during the winter season. Lead loadings in Calgary were greater at the downtown and industrial monitoring locations than at the residential monitoring station. Motor vehicle traffic, which is a major source of lead emissions, is greater at the downtown and industrial locations.

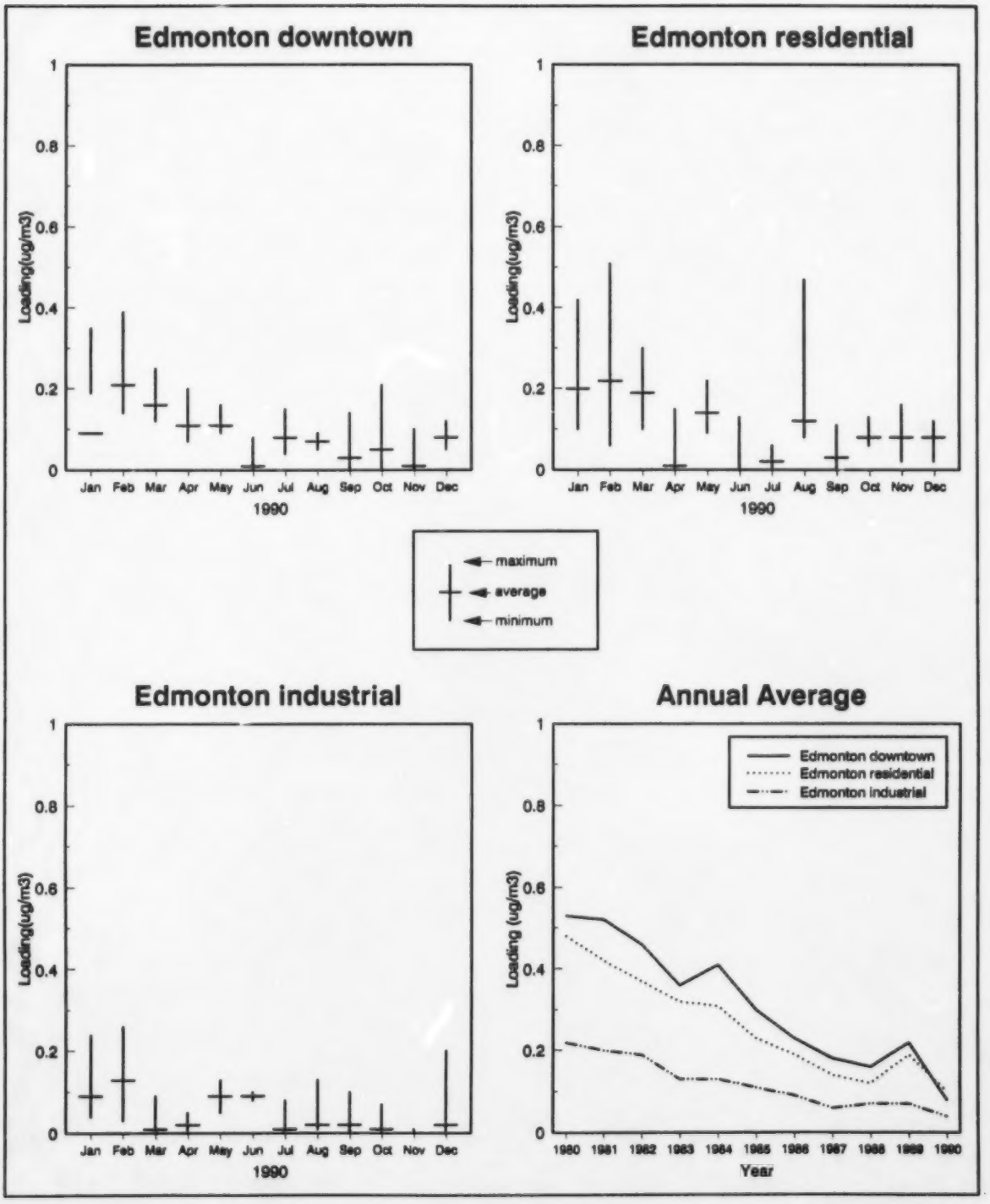

Figure 5-7 Lead loadings at Edmonton.

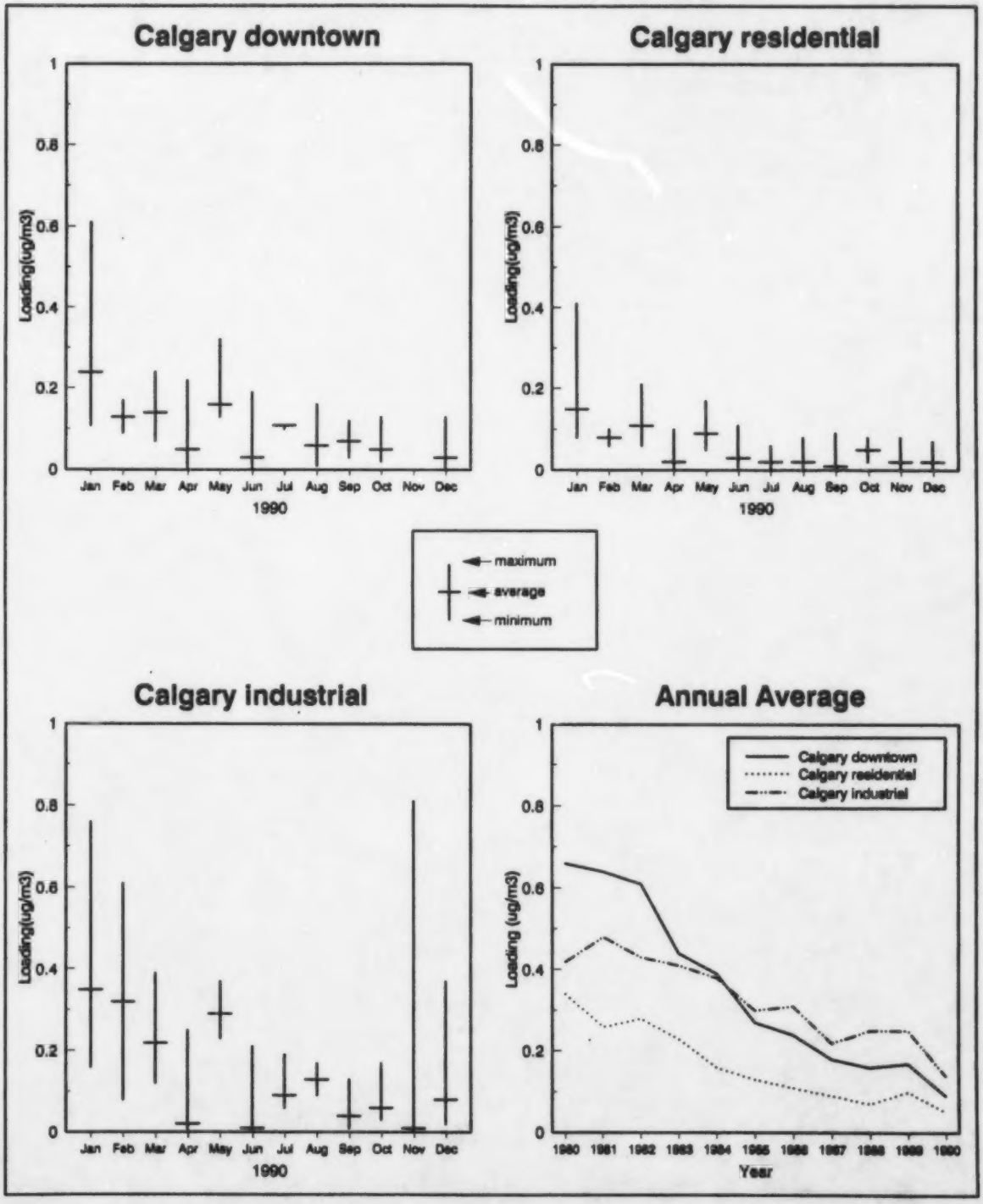

Figure 5-8 Lead loadings at Calgary.

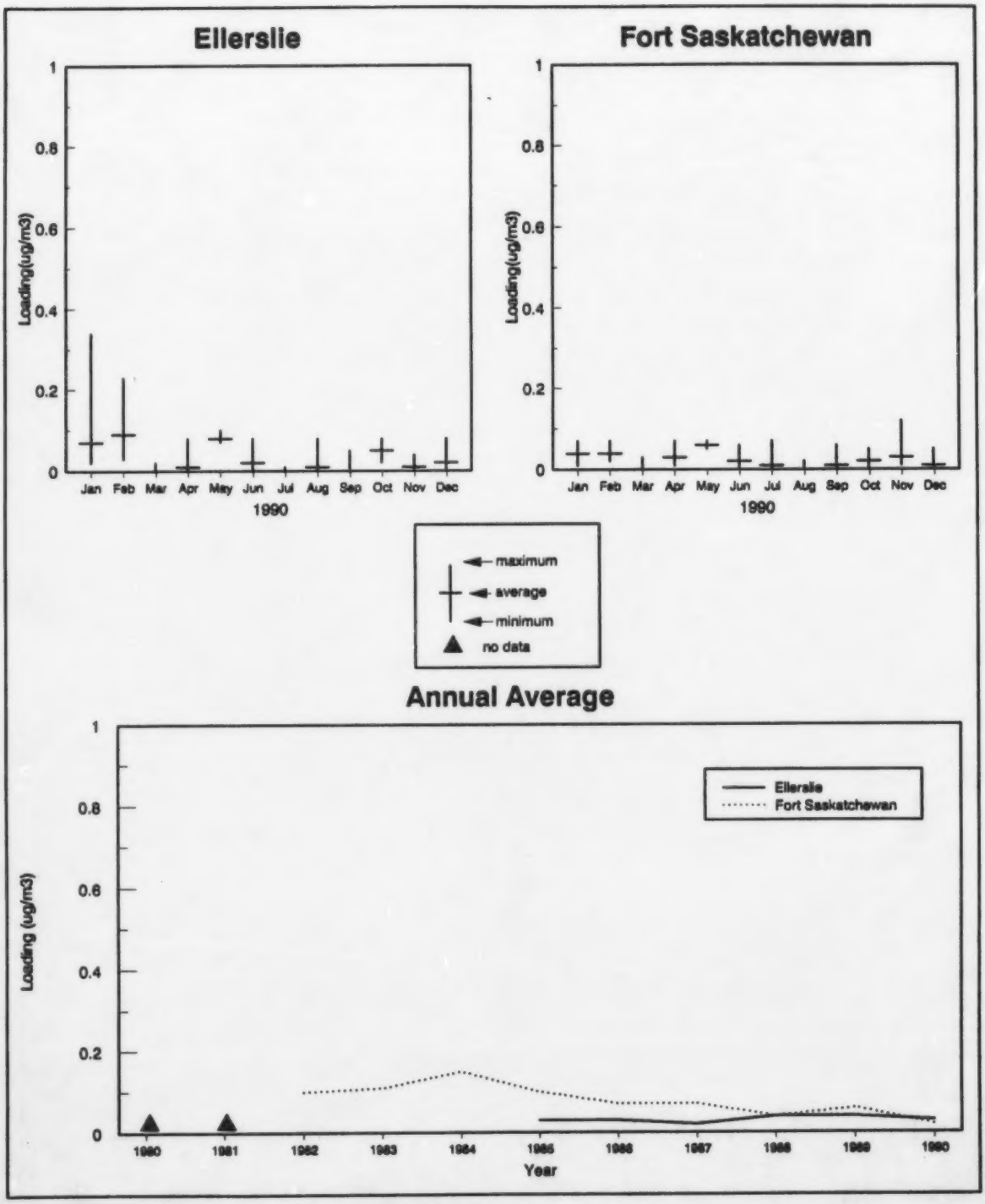

Figure 5-9 Lead loadings at Ellerslie and Fort Saskatchewan.

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5.3.4.3 *Fort Saskatchewan and Ellerslie*

At Fort Saskatchewan and Ellerslie, lead concentrations were consistently lower than at the Edmonton and Calgary monitoring stations. This is because of less vehicular traffic at these two locations. Maximum lead loadings at Fort Saskatchewan and Ellerslie were 0.34 and 0.12 ug/m^3, respectively. These values occurred in January and November, respectively.

5.4 VINYL CHLORIDE MONOMER (VCM)

5.4.1 *Characteristics*

A VCM is a synthetically produced organic molecule that belongs to a group of chemicals known as chlorinated hydrocarbons. This group also includes chloroform, formaldehyde and carbon tetrachloride. Under normal conditions of temperature and pressure, VCM is a colourless gas with a faint, sweet odour. During industrial use chloride monomer is usually stored under its own vapour pressure as a liquid.

VCM is produced synthetically through several chemical reactions that involve the chlorination of ethylene. The chemical industry uses VCM to produce polyvinyl chloride which is a polymer of VCM. Polyvinyl chloride, a form of plastic, is used in the manufacturing of clothing, building and construction materials, home furnishings, packaging and toys.

Prior to and during the polymerization process, VCM may be released into the environment where it will rapidly break down in the presence of sunlight to form carbon oxides, hydrogen chloride and water.

5.4.2 *Method of Monitoring*

The VCM monitoring process involves drawing a known volume of air through a glass tube coated, internally, with spherocarb 60/80. Vinyl chloride gas is adsorbed onto the spherocarb and the tube is sent to a laboratory for analysis. A 24-hour accumulated VCM concentration may than be calculated.

5.4.3 Regulations and Guidelines

Alberta currently regulates VCM emissions by licencing each industrial source and limiting their emissions according to the Clean Air (Maximum Levels) Regulation.

5.4.4 Results

VCM was monitored at three sites in the Fort Saskatchewan region: (1) the Fort Saskatchewan continuous monitoring station; (2) a location west of the Dow Chemical petrochemical processing plant; and (3) west of the BF Goodrich chemical processing plant. These locations were selected because of their proximity to the petrochemical processing industry. Maximum, average and minimum VCM concentrations are presented by month in Figure 5-10.

Average VCM concentrations for the monitoring period ranged from 0.03 ppb at the Fort Saskatchewan monitoring station to 0.06 ppb at the monitoring location near the Dow Chemical plant and 0.11 ppb at the monitoring location near the BF Goodrich plant. Maximum concentrations at these three locations were 0.51, 0.30 and 1.16 ppb, respectively. VCM showed a trend toward lower concentrations in the later part of 1990 at all monitoring stations. For example, no detectable VCM concentrations were recorded from the April to December at the Dow and BF Goodrich monitoring sites. VCM concentrations were not detectable in April, August and October to December at the Fort Saskatchewan monitoring station. Maximum VCM values were observed in July at the Fort Saskatchewan station and January at the Dow and BF Goodrich stations.

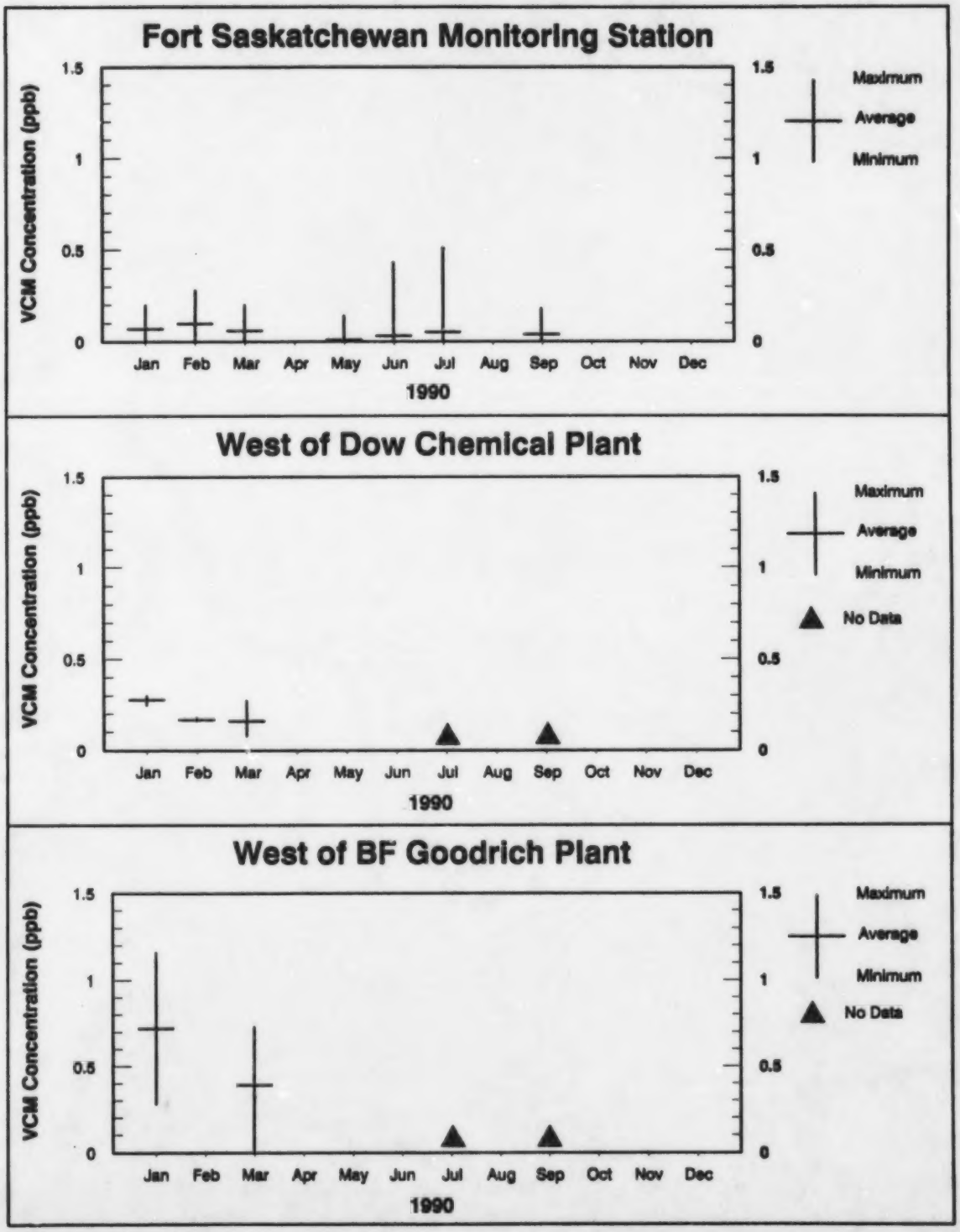

Figure 5-10 Vinyl chloride monomer concentrations in the Fort Saskatchewan region.

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6. STATIC MONITORING RESULTS

6.1 TOTAL DUSTFALL

6.1.1 Characteristics

Dustfall is described as a measurement of the fraction of particulate matter that does not remain suspended in the atmosphere for an indefinite period of time. Particles collected by dustfall monitors will generally have a larger diameter and mass than those collected as suspended particles (see Section 5.1).

Dustfall may originate from a variety of natural and man-made sources. The most common sources are road dust, wind-blown soil, particles generated through agricultural activities (harvest), large particles emanating from industrial sources and ash from forest and recreational fires.

6.1.2 Method of Monitoring

Total dustfall is collected in a vertically erected cylinder containing either water (in the summer) or iso-propyl alcohol (in the winter). Particles settle into the cylinder and onto the surface of the liquid. At the end of the one-month monitoring period, the sample is analyzed to determine the total dustfall loading.

6.1.3 Regulations and Guidelines

The guidelines adopted by Alberta Environment for total dustfall in the ambient air are as follows:

- 53 mg/100 sq cm/30 days (milligrams per 100 square centimeters per 30 days) in residential and recreational areas; and
- 158 mg/100 sq cm/30 days in commercial and industrial areas.

6.1.4 *Results*

Dustfall was monitored at 13 networks by Alberta Environment in 1990. Each network consist of at least one monitoring station which collects total dustfall as an accumulated loading for a period of one month. A total of 67 total dustfall monitoring stations were operated in Alberta during 1990. Figure 6-1 shows the location of total dustfall monitoring networks in Alberta. Table 6.1 summarizes the arithmetic average of total dustfall loadings for each network as well as the frequency of time total dustfall loadings exceeded residential/recreational and industrial/commercial guidelines at each network.

Average total dustfall loadings ranged from 24 mg/100 sq cm/30 days at Fort Saskatchewan to 94 mg/100 sq cm/30 days at Lethbridge. Relatively high annual average dustfall loadings were also measured at Calgary, Edmonton and Exshaw monitoring networks (about 60 mg/100 sq cm/30 days). Exceedances of the residential/recreational guideline for total dustfall were observed at all the monitoring networks, with the exception of Fort Saskatchewan. The highest frequencies of exceedances were recorded at the Calgary, Lethbridge and Exshaw networks where 47, 43 and 36% of observations exceeded the residential/recreational guideline. Exceedances of the commercial/industrial guideline for total dustfall were observed at the Blairmore, Coleman, Edmonton, Exshaw, Lethbridge and Sherwood Park dustfall networks. The highest frequency of exceedances of the commercial/industrial guideline was at the Lethbridge network where 21% of the observations recorded dustfall loadings greater than the regulation.

6.2 CALCIUM

6.2.1 *Characteristics*

The most common natural sources of calcium are wind-blown soil and road dust. Calcium is emitted as particulate matter from processes used in cement, iron, steel, wood and coal manufacturing. The most common compounds of calcium that occur in particulate matter are limestone and gypsum. (Alberta Environment 1985; Environment Canada 1984).

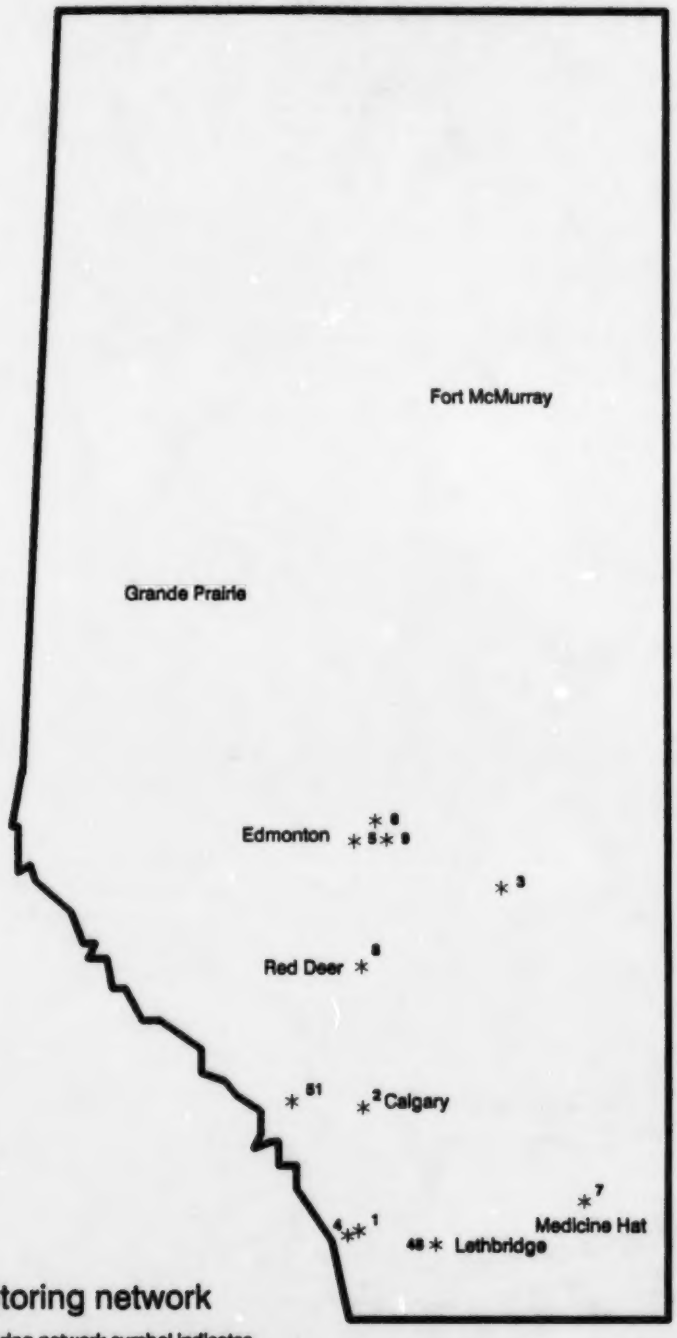

Figure 6-1 Location of total dustfall monitoring networks.

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Table 6.1 Averages and exceedances from networks which monitor total dustfall.

Network Location	# of Stations	Average (mg/100 sq cm/30 days)	Exceedances (percent) a	b	Map Location
Blairmore	2	48	21	4	1
Calgary	3	61	47	0	2
Camrose	1	41	17	0	3
Coleman	11	35	18	1	4
Edmonton	27	60	11	5	5
Edmonton Industrial	1	34	17	0	5
Edmonton Residential	1	26	8	0	5
Exshaw	5	60	36	9	51
Fort Saskatchewan	1	24	0	0	6
Lethbridge	6	94	43	21	48
Medicine Hat	5	39	33	0	7
Red Deer	1	26*	13*	0*	8
Sherwood Park	3	52	21	3	9

a Refers to exceedances of the residential/recreational guideline (53 mg/ 100 sq cm/30 days).

b Refers to exceedances of the industrial/commercial guideline (158 mg/ 100 sq cm/30 days).

* ≥50 to <75% of data available.

** Less than 50% of data available.

6.2.2 *Method of Monitoring*

Calcium loadings at certain stations are obtained by laboratory analysis of the dustfall samples. Analysis for calcium is generally performed on total dustfall samples collected from stations located close to facilities which emit calcium into the atmosphere (i.e., cement processing plants).

6.2.3 *Regulations and Guidelines*

There are no regulations or guidelines for atmospheric calcium loadings in Alberta at the present time.

6.2.4 *Results*

Figure 6-2 indicates the locations where calcium was monitored in 1990. Table 6.2 shows the average and maximum calcium loadings for each network. Average calcium loadings ranged from 1.0 mg/100 sq cm/30 days at the Edmonton residential monitoring station to 14.1 mg/100 sq cm/30 days at the Exshaw monitoring network. A maximum calcium loading of 84.1 mg/100 sq cm/30 days was measured at the Exshaw monitoring network in 1990. The location of the Exshaw monitoring network relative to limestone deposits and a cement manufacturing plant likely explain the high calcium loadings in the vicinity.

6.3 TOTAL SULPHATION

6.3.1 *Characteristics*

Total sulphation includes all sulphur-containing compounds which are present in the ambient air. These compounds include hydrogen sulphide, sulphur dioxide and mercaptans. Sources of sulphur-containing compounds include emissions from sulphur recovery processes at sour gas plants and as a by-product of gasoline and coal combustion.

6.3.2 *Method of Monitoring*

Total sulphation is measured by a sulphation cylinder or a sulphation plate which has a suface that is impregnated with a reactive lead dioxide. Sulphur compounds react with lead dioxide to produce lead sulphide. The quantity of lead sulphide on the surface indicates the total sulphation loading.

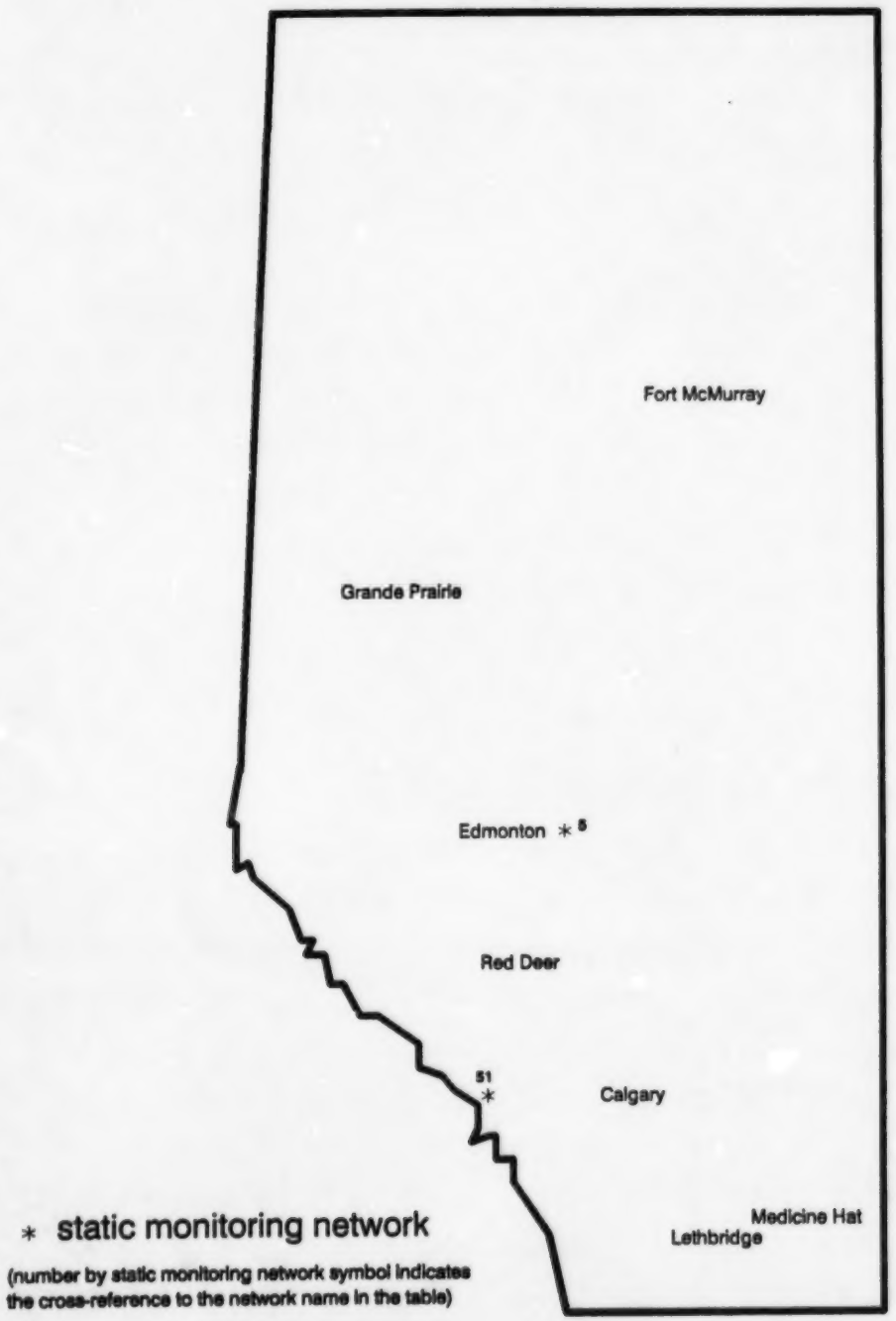

Figure 6-2 Location of calcium monitoring networks.

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Table 6.2 Averages and maximums from networks which monitor calcium.

Network Location	# of Stations	Average (mg/100 sq cm/30 days)	Maximum (mg/100 sq cm/30 days	Map Location
Edmonton	3	6.4	21.1	**5**
Edmonton Industrial	1	2.1	5.1	**5**
Edmonton Residential	1	1.0	2.4	**5**
Exshaw	5	14.1	84.1	**51**

6.3.3 Regulations and Guidelines

The guideline for total sulphation loading in Alberta is:

- 0.50 mg SO_3 equivalent/day/100 sq cm (milligrams as SO_3 per day per 100 square centimetres).

6.3.4 Results

Total sulphation is monitored at 23 networks, on a one-month basis, and 35 networks, on a three-month basis, throughout the province. The length of the exposure period is dependent on the abundance and type of industrial sources in the area.

6.3.4.1 One-Month Exposure Period

A total of 106 static monitoring stations at 23 networks measured total sulphation, on a one-month basis in Alberta during 1990. The location of these networks is indicated in Figure 6-3. The average total sulphation for each network and frequency of exceedances for each network is shown in Table 6.3. There were no exceedances of the regulation for stations which monitor total sulphation on a monthly basis. Average total sulphation values ranged from 0.004 mg/day/100 sq cm at Hinton to 0.077 mg/day/100 sq cm at the Edmonton industrial monitoring network. The maximum total sulphation loading from these networks was 0.318 mg/day/100 sq cm which occurred at the Redwater monitoring network.

Figure 6-3 Location of total sulphation monitoring networks.

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Table 6.3 **Averages and exceedances from networks which monitor total sulphation on a one-month exposure basis.**

Network Location	# of Stations	Average (mg/day/100 sq cm)	Exceedances (percent)	Map Location
Bitumont Tower	1	0.071**	0**	52
Calgary	32	0.067	0	2
Camrose	1	0.047	0	3
Edmonton	27	0.045	0	5
Edmonton Industrial	1	0.077	0	5
Ells Tower	1	0.005**	0**	53
Edmonton Residential	1	0.046	0	5
Fort McMurray	6	0.061	0	22
Fort Saskatchewan	4	0.063	0	6
Fort Saskatchewan (special)	1	0.058	0	6
Grande Prairie	1	0.014	0	23
Hinton	3	0.004	0	24
Joffre	2	0.036*	0*	26
Lethbridge	5	0.031	0	48
Medicine Hat	5	0.026	0	7
Muskey Tower	1	0.068**	0**	55
New Norway	1	0.050*	0*	33
Raven Brood	1	0.020*	0*	49
Red Deer (city)	2	0.033*	0*	8
Redwater	4	0.073	0	50
Sherwood Park	3	0.065	0	9
St. Albert	2	0.011	0	41
Thickwood Tower	1	0.024**	0**	54

a Refers to exceedances of the guideline (0.50 mg/day/100 sq cm).
* ≥50 to <75% of data available.
** Less than 50% of data available.

6.3.4.2 *Three-Month Exposure Period*

A total of 141 stations monitor total sulphation, on a three-month basis, in 35 static monitoring networks in Alberta. The location of these networks is presented in Figure 6-4. Table 6.4 shows average total sulphation values for each network and the frequency of exceedances for each network. Average total sulphation loadings ranged from 0.007 mg/day/100 sq cm at the Bigstone monitoring network (near Whitecourt) to 0.153 mg/day/100 sq cm at the Redwater monitoring network. The Coleman monitoring network also reported a fairly high annual average total sulphation loading (0.104 mg/day/100 sq cm). Relatively high total sulphation observations in the vicinity of Redwater and Coleman are likely the result of gas processing activities in the area. There were no exceedances of the regulation for total sulphation at any of the Alberta Environment networks in 1990. The overall maximum total sulphation loading observed from these networks was 0.276 mg/day/100 sq cm which was recorded at the Redwater monitoring network.

6.4 HYDROGEN SULPHIDE (H_2S)

6.4.1 *Characteristics*

The characteristics of H_2S are described in Section 4.6 of this report. Industrial sources of H_2S include petroleum refining plants, natural gas plants, petrochemical complexes, coke oven plants, and pulp and paper mills employing the kraft pulping process. H_2S occurs naturally in coal, natural gas, oil, sulphur hot springs, sloughs, swamps and lakes.

6.4.2 *Method of Monitoring*

H_2S is monitored by an exposure cylinder or an exposure plate which contains a surface which has been impregnated with zinc acetate. H_2S will react with zinc acetate to form zinc sulphide. The quantity of zinc sulphide on the surface is proportional to the quantity of H_2S deposited onto the surface.

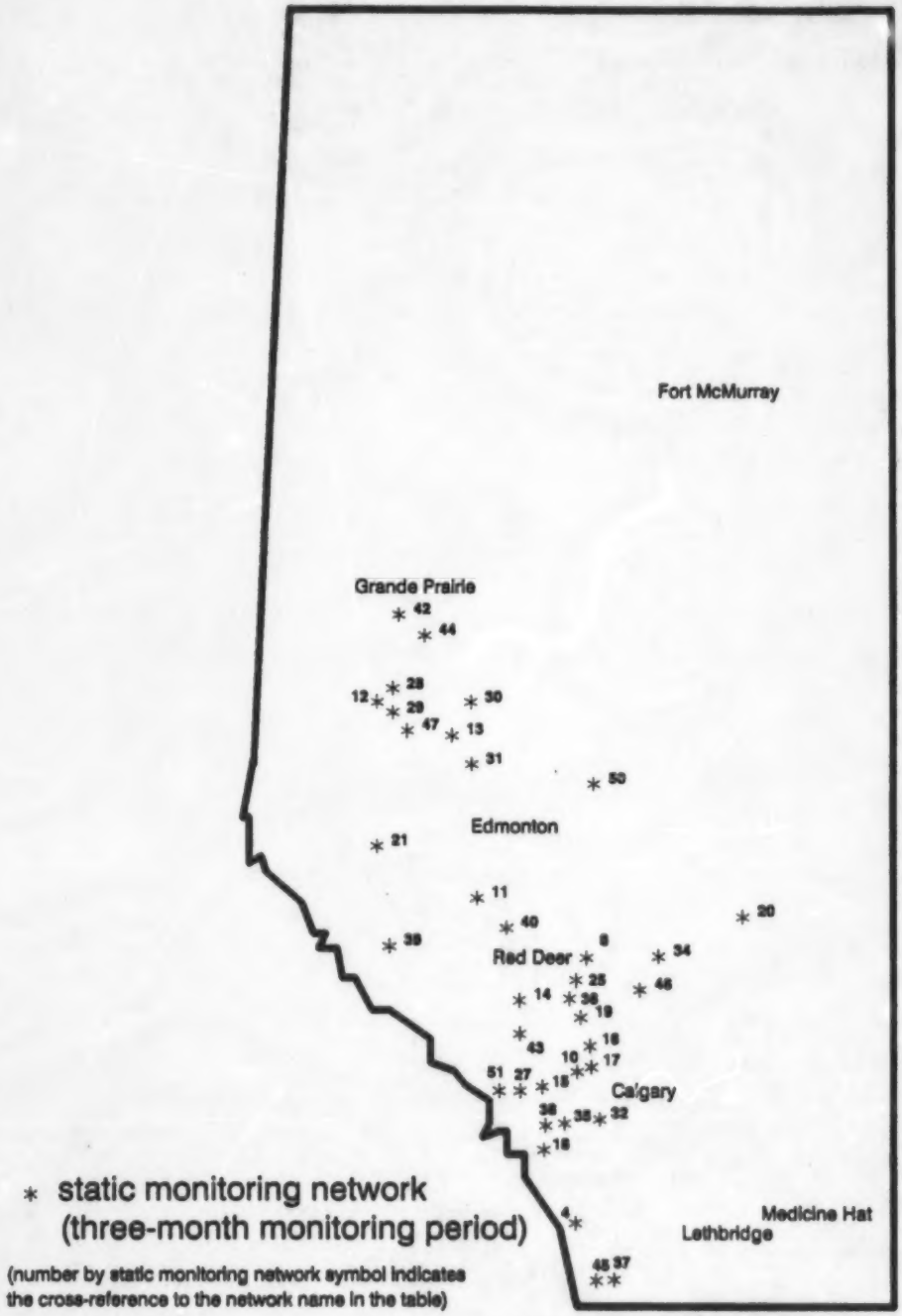

Figure 6-4 Location of total sulphation monitoring networks.

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Table 6.4 **Averages and exceedances from networks which monitor total sulphation on a three-month exposure basis.**

Network Location	# of Stations	Average (mg/day/100 sq cm)	Exceedances (percent)	Map Location
Balzac	4	0.060	0	10
Bigstone	2	0.007**	0**	12
Blue Ridge	4	0.043**	0**	13
Buck Lake	4	0.039*	0*	11
Caroline	2	0.035	0	14
Carstairs	4	0.041	0	16
Cochrane	4	0.067	0	15
Coleman	4	0.104	0	4
Crossfield	5	0.063	0	17
Diamond Valley	4	0.034	0	18
Didsbury	7	0.037*	0*	19
Edburg	1	0.050*	0*	20
Edson	4	0.023	0	21
Innisfail	4	0.060*	0*	25
Jumping Pound	4	0.050	0	27
Kaybob	4	0.040**	0**	28
Kaybob (south)	4	0.061**	0**	29
Lone Pine Creek	5	0.050	0	30
Mayerthorpe	2	0.028	0	31
Mazeppa	4	0.043	0	32
Nevis	7	0.048*	0*	34
Okotoks	5	0.054	0	35
Olds	4	0.060*	0*	36
Pincher Creek	6	0.033	0	37
Quirk Creek	6	0.036	0	38
Ram River	5	0.052*	0*	39
Red Deer	4	0.036*	0*	8
Redwater	4	0.153	0	50
Rimbey	4	0.041*	0*	40
Simonette	2	0.030**	0**	42
Sundre	2	0.060*	0*	43
Valleyview	2	0.078**	0**	44
Waterton	8	0.072	0	45
Wimborne	2	0.068*	0*	46
Windfall	4	0.086**	0**	47

a Refers to exceedances of the guideline (0.50 mg/day/100 sq cm).
* ≥50 to <75% of data available.
** Less than 50% of data available.

6.4.3 *Regulations and Guidelines*

The guideline for H_2S loading in Alberta is:

- 0.10 mg SO_3 equivalent/day/100 sq cm (milligrams as SO_3 per day per 100 square centimetres).

6.4.4 *Results*

H_2S is monitored on a one-month and three-month basis in the province. A total of 14 networks monitor H_2S on a one-month basis while 35 networks monitor H_2S on a three-month basis.

6.4.4.1 *One-Month Exposure Period*

A total of 26 static monitoring stations measure H_2S, on a one-month basis in Alberta. Figure 6-5 shows the location of these networks. Average H_2S loadings and exceedances of the guideline for each network are shown in Table 6.5. Average H_2S loadings ranged from 0.001 mg/day/100 sq cm at Fort Saskatchewan to 0.014 mg/day/100 sq cm at the Fort McMurray and Grande Prairie monitoring networks. No exceedances of the guideline for H_2S were observed in 1990. A maximum observed monthly H_2S loading of 0.056 mg/day/100 sq cm was recorded at Fort McMurray.

6.4.4.2 *Three-Month Exposure Period*

A total of 144 static monitoring stations, in 35 networks, measure H_2S on a three-month basis in Alberta. Figure 6-6 shows the location of H_2S networks administered by Alberta Environment in 1990. Average H_2S loadings for each network and the frequency of exceedances are shown in Table 6.6. Exceedances of the guideline were not recorded at networks which monitor H_2S on a three-month basis. The highest annual average H_2S loading was observed at the Redwater network where a value of 0.013 mg/day/100 sq cm was recorded. The overall maximum H_2S loading was 0.036 mg/day/100 sq cm which was measured at Redwater.

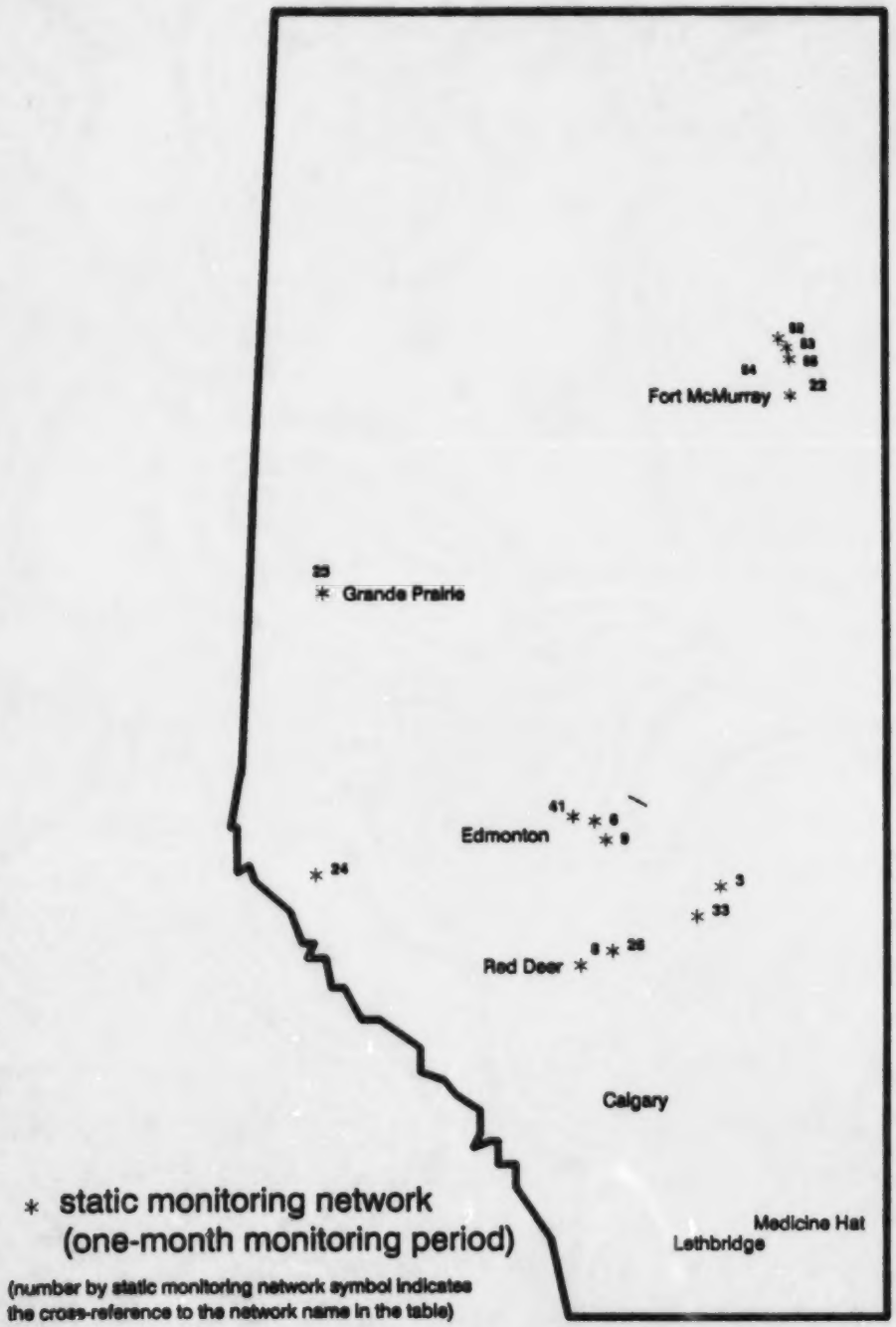

Figure 6-5 Location of hydrogen sulphide monitoring networks.

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Table 6.5 Averages and exceedances from networks which monitor hydrogen sulphide on a one-month exposure basis.

Network Location	# of Stations	Average (mg/day/100 sq cm)	Exceedances (percent)	Map Location
Bitumont Tower	1	0.008**	0**	52
Camrose	1	0.008	0	3
Ells Tower	1	0.004**	0**	53
Fort McMurray	6	0.014	0	22
Fort Saskatchewan	1	0.001	0	6
Grande Prairie	1	0.014	0	23
Hinton	3	0.002	0	24
Joffre	2	0.009*	0*	26
Muskeg Tower	1	0.008**	0**	55
New Norway	1	0.009*	0*	33
Red Deer (city)	2	0.007*	0*	8
Sherwood Park	3	0.011	0	9
St. Albert	2	0.004	0	41
Thickwood Tower	1	0.002**	0**	54

a Refers to exceedances of the guideline (0.10 mg/day/100 sq cm).
* ≥50 to <75% of data available.
** Less than 50% of data available.

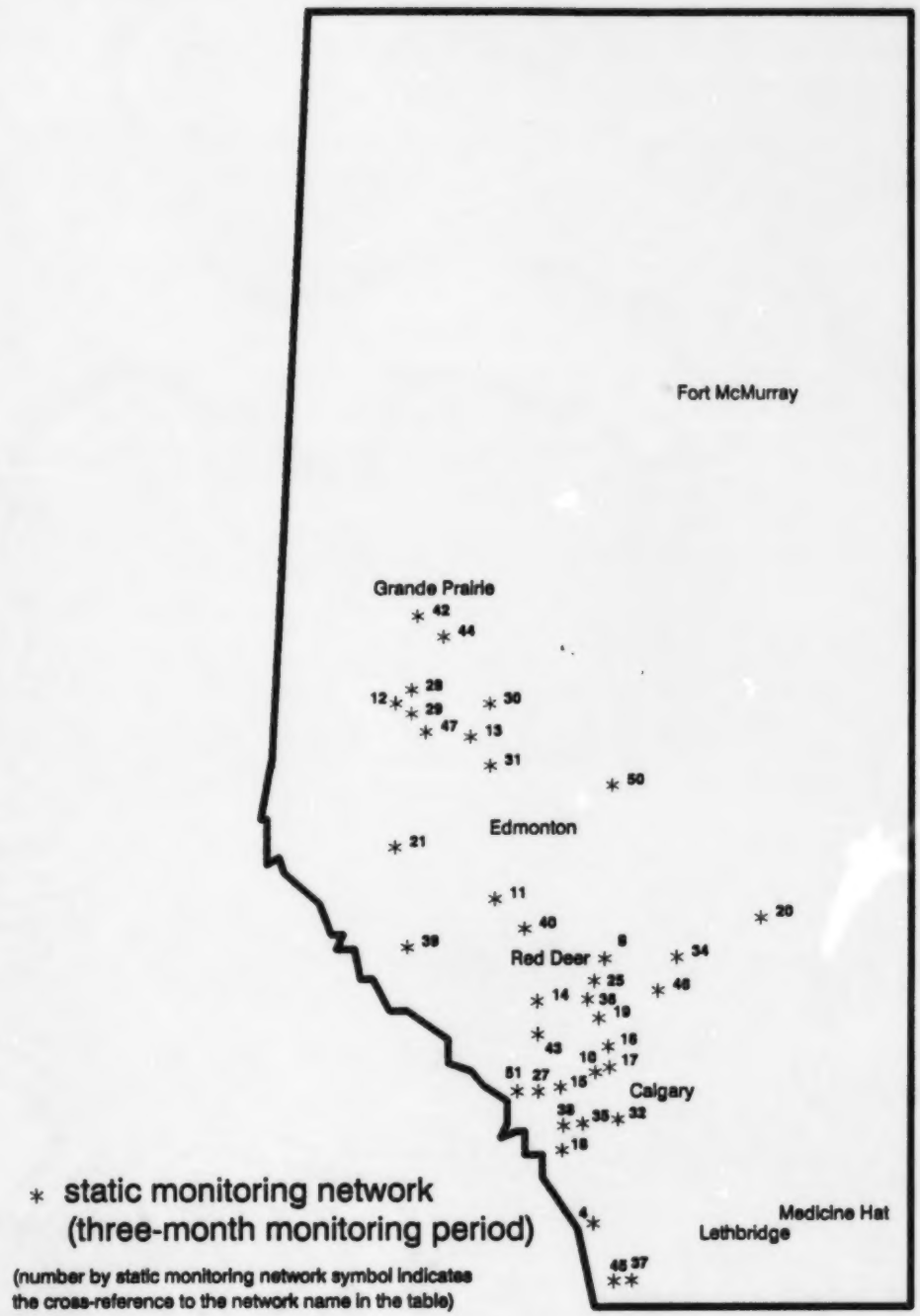

Figure 6-6 Location of hydrogen sulphide monitoring networks.

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Environmental Assessment Division
Environmental Quality Monitoring Branch

Table 6.6 Averages and exceedances from networks which monitor hydrogen sulphide on a three-month exposure basis.

Network Location	# of Stations	Average (mg/day/100 sq cm)	Exceedances (percent)	Map Location
Balzac	4	0.006	0	10
Bigstone	2	0.001**	0**	12
Blue Ridge	4	0.001**	0**	13
Buck Lake	4	0.002*	0*	11
Caroline	2	0.001*	0*	14
Carstairs	4	0.004	0	16
Cochrane	4	0.008	0	15
Coleman	4	0.008	0	4
Crossfield	5	0.004	0	17
Diamond Valley	4	0.002	0	18
Didsbury	8	0.002*	0*	19
Edburg	1	0.003**	0**	20
Edson	4	0.002	0	21
Innisfail	4	0.002*	0*	25
Jumping Pound	4	0.005	0	27
Kaybob	4	0.001**	0**	28
Kaybob (south)	4	0.002**	0**	29
Lone Pine Creek	5	0.003	0	30
Mayerthorpe	2	0.001**	0**	31
Mazeppa	4	0.001	0	32
Nevis	7	0.002*	0*	34
Okotoks	5	0.004	0	35
Olds	4	0.001*	0*	36
Pincher Creek	6	0.002	0	37
Quirk Creek	6	0.002	0	38
Ram River	5	0.003*	0*	39
Red Deer	4	0.002*	0*	8
Redwater	4	0.013	0	50
Rimbey	4	0.002*	0*	40
Simonette	2	0.001**	0**	42
Sundre	2	0.002**	0**	43
Valleyview	2	0.002**	0**	44
Waterton	8	0.004	0	45
Wimborne	4	0.002*	0*	46
Windfall	4	0.004**	0**	47

a Refers to exceedances of the guideline (0.10 mg/day/100 sq cm).
* ≥50 to <75% of data available.
** Less than 50% of data available.

6.5 FLUORIDES

6.5.1 Characteristics

Fluorides are discharged into the atmosphere by industrial operations which involve the combustion of coal, and the processing of phosphate bearing rock. These industrial processes include: the grinding, drying and calcining of phosphate rock for fertilizer; iron and steel production; kiln firing of ceramic materials for bricks; melting of materials for glassmaking and fluoride-based cleaning; and etching and electroplating agents used in manufacturing.

6.5.2 Method of Monitoring

Total fluoride loading is monitored on a monthly basis. Fluorides are collected on a sample plate lined with calcium oxide saturated filter paper. The fluorides settle onto the plate, in particulate form, and are retained by the calcium oxide. The filter paper is then sent to a laboratory for analysis.

6.5.3 Regulations and Guidelines

In Alberta, industrial sources of fluorides are required to conduct static monitoring. The guideline for fluoride loading is:

- 40.0 ug water soluble fluorides/100 sq cm /30 days (micrograms of water soluble fluorides per 100 square centimetres per 30 days).

6.5.4 Results

Fluorides were monitored by Alberta Environment at Fort Saskatchewan, Medicine Hat and Redwater in 1990. These stations are located near industries, such as brick and tile manufacturing, that are industrial sources of fluorides. Figure 6-7 shows the location of these monitoring networks. Table 6.7 indicates the average fluoride loading for each network and the frequency of exceedances for each network.

Average flouride loadings ranged from 4 ug/100 sq cm/30 days at Fort Saskatchewan to 13 ug/100 sq cm/30 days at the Medicine Hat monitoring network. Exceedances of the guideline for fluoride did not occur in 1990. The maximum fluoride loading was 23 ug/100 sq cm/30 days which was recorded at Medicine Hat.

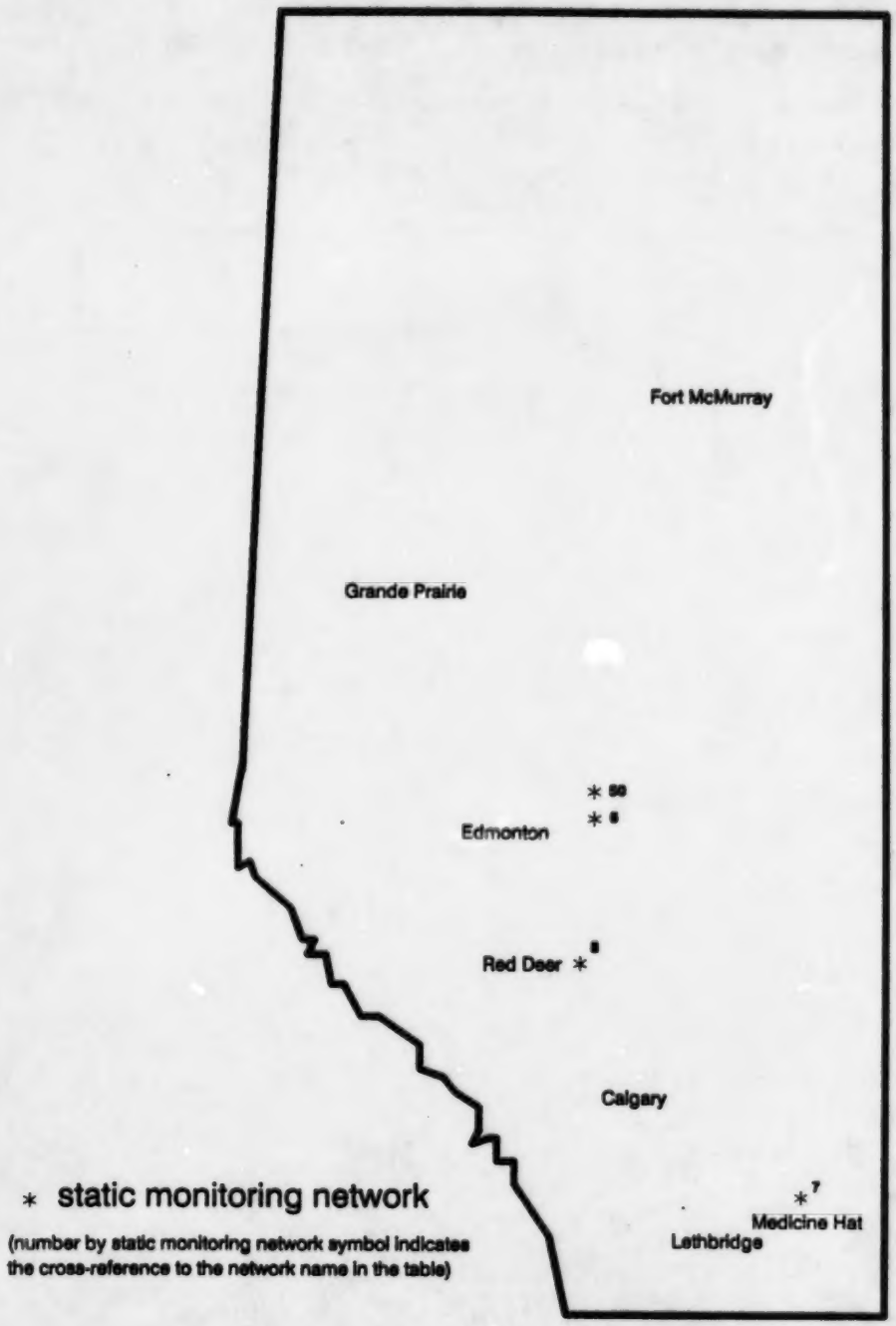

Figure 6-7 Location of fluoride monitoring networks.

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Table 6.7 Averages and exceedances from networks which monitor fluorides.

Network Location	# of Stations	Average (ug/100 sq cm/30 days)	Exceedances (percent)	Map Location
Fort Saskatchewan	1	4	0	6
Medicine Hat	1	7**	0**	7
Redwater	4	8	0	50

a Refers to exceedances of the guideline (40.0 ug/100 sq cm/30 days).
* ≥50 to <75% of data available.
** Less than 50% of data available.

7. ACID PRECIPITATION MONITORING RESULTS

7.1 CHARACTERISTICS

There is an increasing public awareness of the occurrence and effects of acidic substances in the atmosphere. Acidic substances contained in the atmosphere will eventually be deposited on the earth's surface in the form of precipitation (wet deposition) or particulates and gases (dry deposition).

The effects of acid deposition vary depending on the amount of acidic pollutants being deposited and the buffering capacity (ability of soil or water to neutralize the acidity of the precipitation) of the receptor. In the eastern North America and Europe, changes in aquatic life, changes to forest and crop growth, and damage buildings and equipment have been attributed to acid deposition.

Since 1978, precipitation chemistry measurements have been conducted by Alberta Environment. The objectives of the acid precipitation program are to: (1) monitor the quality of precipitation; (2) detect any significant trends in precipitation quality; and (3) determine long-range transport of pollutants into the province.

7.2 METHOD OF MONITORING

Precipitation is collected by a sampler that opens automatically when precipitation (rain or snow) occurs and closes when the precipitation ceases. Each month, the sample is retrieved from the field and sent to the laboratory for analysis. Data obtained as a result of analysis include pH, strong acidity, total acidity, specific conductance, major cations (calcium, ammonium, sodium, magnesium and potassium) and major anions (sulphate, nitrate, chloride and phosphate).

7.3 REGULATIONS AND GUIDELINES

Wet sulphate deposition is often used as an indicator of wet deposition. In eastern Canada, the relationship between hydrogen and sulphate ions is strong enough to establish a basis for wet deposition standards. An objective of 20 kg/ha/yr (kilograms per hectare per year) has been adopted for wet sulphate deposition in eastern Canada.

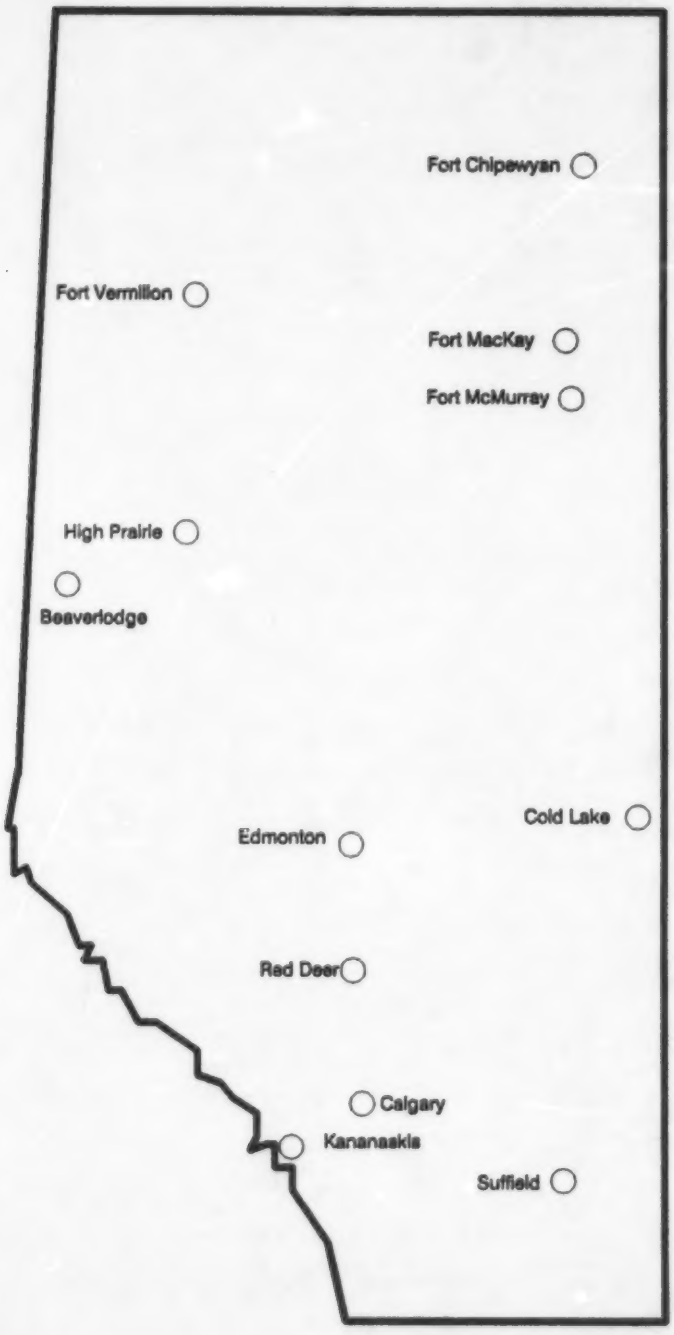
Analysis of acid precipitation data gathered in western Canada has revealed that the hydrogen-sulphate ion relationship is not strong enough to use as a basis for wet deposition standards (Lau 1982; Sandhu and Blower 1986; Bertram et al. 1987; Legge 1988). Other ions such as calcium and magnesium are associated with sulphate ions to form non-acidifying substances such as calcium sulphate and magnesium sulphate. An approach has been developed to take into account the acidifying potential of precipitation after the removal of non-acidifying substances. A range of interim critical loadings has been recommended for western and northern Canada (Interim Acid Deposition Critical Loadings Task Group 1990). This approach is currently being considered by Alberta Environment.

7.4 RESULTS

The locations of Alberta Environment precipitation monitoring stations are indicated in Figure 7-1. Table 7.1 shows the volume-weighted average pH of precipitation samples collected at Alberta Environment monitoring stations in 1990. Also indicated in this table are wet deposition rates of anions and cations contained in the precipitation samples. Wet deposition rates are presented in units of kilograms per hectare per year which essentially is the total mass of a specific contaminant deposited onto one hectare during the period of one year by the process of precipitation. Greater than or equal to 75% of data must be available to compute accurate annual wet deposition rates. Wet deposition estimates are not available for Fort MacKay due to a lack of data.

7.4.1 pH

Uncontaminated precipitation is slightly acidic (pH of 5.6) due to the presence of carbon dioxide. When pollutants such as sulphur dioxide and nitric oxides are emitted into the atmosphere, sulphates and nitrates are formed through oxidation. Sulphates and nitrates combine with water vapour to form sulphuric and nitric acids. The presence of these acids causes precipitation to become more acidic (lower pH).



○ acid precipitation monitoring network

Figure 7-1 Location of acid precipitation monitoring stations.

Table 7.1 pH and wet deposition rates for anions and cations at acid precipitation monitoring stations.

Station	pH	Anions (kg/ha/yr)				Cations (kg/ha/yr)				
		$SO_4^=$	NO_3^-	Cl^-	$PO_4^=$	Ca^{++}	NH_4^+	Na^+	Mg^{++}	K^+
Beaverlodge	5.1	2.4	1.7	0.3	0.0	0.3	0.2	0.1	0.0	0.1
Calgary	5.8	4.5	3.4	0.4	0.0	1.0	1.5	0.2	0.2	0.3
Cold Lake	5.7	3.4	2.7	0.4	0.5	0.7	1.6	0.2	0.2	0.4
Edmonton	5.3	5.9	4.0	0.6	0.0	1.2	1.7	0.3	0.2	0.3
Fort Chipewyan	5.2	1.5	1.0	0.4	0.0	0.3	0.1	0.2	0.1	0.2
Fort MacKay	4.8**	**	**	**	**	**	**	**	**	**
Fort McMurray	5.0	5.2	2.8	1.5	0.0	1.5	0.4	0.7	0.5	0.3
Fort Vermillion	5.3	2.5	2.0	0.4	0.0	0.6	0.4	0.2	0.1	0.2
High Prairie	6.0	4.2	2.6	0.8	0.4	2.2	1.2	0.2	0.8	1.6
Kananaskis	5.1	5.6	4.8	0.5	0.0	1.1	1.0	0.2	0.2	0.1
Red Deer	5.5	6.9	5.3	0.4	0.0	1.4	2.2	0.2	0.3	0.2
Suffield	5.9	5.3	3.7	0.6	0.4	1.2	2.2	0.5	0.4	0.6

* ≥50 to <75% of data available.
** Less than 50% of data available.

The most acidic precipitation in 1990 occurred at Fort MacKay, Fort McMurray, Beaverlodge and Kananaskis with volume weighted annual average pH values of less than or equal to 5.1. The pH at Fort MacKay is based on only one month of data and is likely not representative of the entire year. Relatively low annual average pH values were also measured at the Edmonton, Fort Chipewyan and Fort Vermilion precipitation stations. The lowest monthly pH recorded in Alberta was 4.59 which was recorded at the Edmonton (Ellerslie) precipitation monitoring site in September. Values of monthly pH less than 5.0 were observed at all Alberta Environment precipitation monitoring stations. Annual average pH values close that of uncontaminated precipitation (pH of 5.6) were indicated at Cold Lake and Red Deer.

The highest annual average pH values were recorded at High Prairie, Suffield and Calgary. The pH of precipitation was 5.8 or greater at these locations. The overall maximum monthly pH was measured at High Prairie where a value of 7.47 was recorded in December. Monthly pH values greater than 7.0 were measured at Fort McMurray, High Prairie and Red Deer.

7.1.2 Anions (sulphate, nitrate, chloride, phosphate)

Anions are negatively charged groups of atoms or molecules formed when chemicals dissociate in water. Sulphuric acid and nitric acid produce sulphate and nitrate ions, respectively, and these are often used as a measure of acidity. Parent chemicals may be emitted into the atmosphere by gas plants, oil sands plants, coal-fired power plants, oil refineries, pulp and paper mills, fertilizer plants and agricultural activities.

The highest overall wet sulphate deposition rate occurred at Red Deer where a value of 6.9 kg/ha/yr was recorded. Relatively high wet sulphate deposition rates were also recorded at Edmonton, Fort McMurray and Kananaskis where values of 5.2 kg/ha/yr or greater were measured. These values are well below the eastern Canada objective of 20 kg/ha/yr for wet sulphate. The lowest wet sulphate deposition values were recorded at Fort Chipewyan (1.5 kg/ha/yr), Beaverlodge (2.4 kg/ha/yr) and Fort Vermilion (2.5 kg/ha/yr). Sulphate deposition values are not available at Fort McMurray because less than 75% of data was available.

Maximum values of wet nitrate deposition were recorded at Red Deer (5.3 kg/ha/yr) and Kananaskis (4.8 kg/ha/yr). Minimum rates were observed at Fort Chipewyan (1.0 kg/ha/yr) and Beaverlodge (1.7 kg/ha/yr).

Wet chloride deposition rates ranged from 0.3 kg/ha/yr at Beaverlodge to 1.5 kg/ha/yr at Fort McMurray. Chloride deposition rates at all other precipiation stations were in the 0.4 to 0.8 kg/ha/yr range.

Wet phosphate deposition rates were relatively low at all monitoring stations. A maximum phosphate deposition rate of 0.5 kg/ha/yr was recorded at Cold Lake.

7.1.3 Cations (calcium, ammonium, sodium, magnesium, potassium)

Cations are positively charge groups of atoms or molecules formed when chemical compounds dissociate in water. All solutions are electronically neutral and, therefore, each anion will be balanced by a cation. Many parent chemicals will emanate from industrial sources such as iron, steel, wood, coal and cement manufacturing. A large percentage of cations will also be contained in wind-blown soil and dust.

Wet calcium deposition was a maximum at High Prairie where a value of 2.2 kg/ha/yr was recorded. Minimum wet calcium deposition rates were recorded at Beaverlodge (0.3 kg/ha/yr) and Fort Chipewyan (0.3 kg/ha/yr).

Maximum ammonium wet deposition rates were observed at Red Deer and Suffield where a deposition rate of 2.2 kg/ha/yr was recorded at both stations. A minimum value of 0.1 kg/ha/yr was observed at Fort Chipewyan.

Wet potassium and magnesium deposition rates were a maximum at High Prairie with values of 1.6 and 0.8 kg/ha/yr, respectively. Wet sodium deposition rates ranged from 0.1 kg/ha/yr at Beaverlodge and Kananaskis to 0.7 kg/ha/yr at Fort McMurray.

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